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INDIAN TEA
ITS CULTURE AND MANUFACTURE

INDIAN TEA

A TEXTBOOK ON THE CULTURE
AND MANUFACTURE OF TEA

BY

CLAUD BALD

SIXTH EDITION

REWRITTEN BY

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PREFACE TO FIFTH EDITION

SINCE the last edition of this book was published many important modifications and advances have occurred in almost every branch of the culture of tea. Very considerable revision, and in places, complete rewriting of the original text has been necessary in order to bring the book up to date.

In carrying out this revision the editor has tried as far as possible to maintain the original style and format which have in the past contributed in no small measure to the success of the book and to its value as a source of ready reference on most matters connected with the culture of tea.

Care has been taken to explain in simple terms the meaning of technical words and vernacular terms occurring in the text, and it is hoped that the book may prove as useful to the young planter starting his career in tea as to his more experienced colleague.

The editor takes this opportunity of thanking all those who have given their expert assistance in revising various sections. Without this help and advice both practical and scientific, it would have been impossible to attempt the task of making many of the chapters authoritative and up to date.

C. J. H.

PREFACE TO SIXTH EDITION

THE previous edition of this book having been out of print for some time, a sixth edition is called for.

The principles underlying tea planting and manufacture have changed but little, and in general this edition differs only in minor respect from the former.

The chapter on Forestry has been extended to include information on food, fodder and cash crops which may with advantage be grown on land not occupied by tea.

The chapter on Tea Garden Labour and Houses includes notes on water supplies and their treatment to render them potable.

Certain tables in the Appendix have been enlarged.

C. J. H.

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INDIAN TEA

CHAPTER I

CULTIVATION

IMPORTANCE OF CULTIVATION

CULTIVATION is perhaps one of the most important operations on a tea estate and yet in the large majority of gardens there is no class of work which receives less study or attention. The policy has too often been one of following blindly time-honoured customs or methods adopted from other agricultural industries, without stopping to enquire into their suitability when applied to the culture of tea. This policy may be justified on the score of safety, in the absence of definite evidence proving the methods to be wrong, but there should be a readiness to alter or modify such methods, when experiments indicate the advisability of so doing. In tea culture it is supremely necessary to get all the aid obtainable from science and experience, because the circumstances are unique, and the details of this work require as much attention as in any other branch of agriculture. The tea plant being perennial, its culture must inevitably be different from ordinary farm practice where annual crops are raised, and where the principal cultivation is done at a time when there is no crop in the ground. It is different even from fruit farming or coffee growing, where the harvest time is but one month in the year, whereas the tea plant is yielding its crop continuously for eight months on end, and in some places for the whole year round. Hence it follows that mistaken ideas regarding the nature of plant growth or a systematic ignoring of the principles of the science of agriculture may, and does, result in loss of crop, with more or less permanent damage to the plant which yields it.

HOW PLANTS FEED AND GROW

The complex substances of which any plant consists are built up from simple substances absorbed either from the air by the leaves, or from the soil by the roots. The leaves absorb the gases, oxygen and carbon dioxide (carbonic acid gas), while the roots absorb a water solution of a variety of salts, such as the nitrates, phosphates and sulphates of potash, soda, lime, iron, etc. All of these substances are necessary in varying quantities to the health of the plant. The chief constituents of the plant are however carbon, oxygen, nitrogen and hydrogen, and one important fact to bear in mind is that carbon is obtained entirely from the air while nitrogen is taken up by the plant from the soil. All of these simple substances absorbed by the plant are built up in its leaves, under the influence of sunlight and the green colouring matter (chlorophyll) of the leaves, to produce the very complex material which goes to form new plant growth.

OBJECT OF CULTIVATION

The first object of cultivation is to kill or dispose of such vegetation as may be found occupying the ground, including all plants and trees whose presence is inimical to the health or prosperity of the tea plant.

ORGANIC MATTER

In what is called virgin soil, the surface is covered with a layer, more or less thick, of vegetable deposit or mould, the produce of rotted leaves and other decayed vegetation accumulated for many years. This is the source of the soil's organic matter, on which the natural fertility of a soil depends. Organic matter produces what is known as good soil tilth, which may be defined as that friable condition of a soil which renders it easily pulverized, as opposed to breaking into hard clods under the hoe. The importance of soil organic matter lies in the fact that it contains nitrogen, the essential plant food,

in combination with carbon, oxygen and hydrogen. Nitrogen in soil organic matter is insoluble in water and therefore not available to growing plants, but cultivation results in the breaking down of the complex organic matter, converting the nitrogen into soluble nitrates which are absorbed by the plant through its roots. This is, in part at least, the explanation of the temporary increase in the rate of growth, or flushing of the tea bush often observed after a round of hoeing in the rains. Since the remainder of the organic matter returns to the air as carbon dioxide and to the soil as water, it is obvious that cultivation feeds the plant at the expense of the soil's organic matter. The more a soil is cultivated, the better the supply of food to the plant, but, at the same time. the more rapid is the deterioration of the soil. The aim of cultivation should therefore be to provide an adequate and steady supply of available food to the plant, with as little loss of soil organic matter as possible.

CULTIVATION PRIMARILY FOR WEED SUPPRESSION

In order to employ the operation of cultivation to the best effect, a knowledge of the way in which cultivation acts, and its effect on the soil under different conditions, is essential.

As previously stated, the first object of cultivation is to remove vegetation, the presence of which is harmful to the tea bush. Every growing plant is a bad neighbour. In other words, it has a harmful effect on any other plant in its immediate vicinity, firstly because it is in competition with its neighbours for water and plant food in the soil, and secondly because its roots excrete substances which are toxic to those micro-organism in the soil whose work it is to break down the soil organic matter and set free available plant food (nitrate). It is desirable therefore to suppress any crop except that which is required, in order that the required crop shall have its maximum supply of water and available plant food. The removal of water by weeds is undesirable in the dry period of the year, when the tea bush needs

all the water it can get. It is of especial importance that young tea with its comparatively shallow rooting system shall be as free as possible from weeds during the dry cold weather and early spring. In periods of excessive rainfall, weeds may absorb some of the excess water, but their presence on the land, besides limiting the supply of plant food to the tea bush, holds up surface water which would otherwise run off, and so tends to increase the chances of the soil becoming water-logged. There is thus ample reason for keeping the soil free from weeds throughout the year.

Weeds and other plants, while growing on a soil, prevent rapid decomposition of organic matter in the soil, and when these plants die they supply fresh organic matter to the soil, so that by keeping an area continually free from weeds by cultivation, the loss of organic matter is made more rapid. This loss of organic matter can however be greatly minimized by producing vigorous bushes which occupy the soil completely with their roots, and provide a good shade by their canopy above ground. On such well-shaded areas weeds grow poorly. Cultivation may be reduced to a minimum, and the organic matter from the tea prunings and shade trees allowed to accumulate in the soil. These conditions approach closely to those of the virgin forest in which there is no soil cultivation, and organic matter from decaying vegetable matter accumulates steadily. Of course in the case of tea, we are removing annually some of the organic matter in the form of the crop, but the amount removed is very small compared with that returned to the soil in the form of prunings and shade tree droppings. It is estimated that on normal healthy tea at least five times as much new organic matter goes into the soil annually, as is removed by crop. If loss of organic matter is reduced to a minimum by reducing soil stirring to a minimum, then there never need be any fear of soil deterioration under mature healthy tea. On young tea, which has little covering power, a leguminous crop such as *boga medeloa* (Tephrosia candida) may be used with advantage to assist in keeping down weed growth, by

virtue of its shade. At the same time, loppings from the green crop augment the organic matter in the soil.

SOIL STIRRING

An effect of less importance than the destruction of weeds is the stirring of the soil by cultivation, in which soil from lower layers is mixed with that of the upper layer thus increasing aeration. It is this aeration which increases the rate of decomposition of soil organic matter and so increases the rate of formation of soluble nitrogen. Soil stirring was at one time considered necessary after the application of large quantities of bulk organic manures, e.g., green crops, but recent experiments show that, except to minimise risk of fire, there is nothing to be gained by hoeing bulk manures into the soil.

Soil stirring is well known to have an effect on the tilth of the soil. If done on a moist soil during a period of dry weather, it breaks the contact between the stirred soil and the wet subsoil, and thus allows the stirred soil to dry out. A wet sticky clay, cultivated in a spell of dry weather, will become less sticky on drying out, and its tilth will be improved. Sandy loams and sands which never become sticky or in poor tilth when wet, would not be expected to benefit in the above way from soil stirring.

MULCH TO CONSERVE MOISTURE

When a soil is likely to suffer from drought, the cultivation of the upper layer of 3 or 4 inches produces a mulch which prevents to some extent the drying out of soil at lower levels. Under normal conditions, in tea, this effect in conserving moisture is probably very small and of little importance, except possibly in the case of tea nurseries.

PUDDLING SOIL BY CULTIVATION

Though soil stirring may improve a stiff soil if done during dry weather, it has the opposite effect when the

soil is very wet, as the clay is then worked into a sticky condition, rendering the soil less permeable. A soil in such a condition dries out hard and brick-like, so that subsequent cultivation becomes an extremely arduous task.

"CHEELING" OR SURFACE SCRAPING

An efficient means of suppressing weeds during the wet weather, with a minimum of soil stirring, is provided by the operation of scraping the weeds from the surface, together with a minimum of soil. The weeds are scraped from between the rows of tea and piled in ridges in alternate rows.

This method of cultivation has become very popular in recent years. A specially shaped "Cheeling" hoe, broader and shallower than the ordinary *Kodali* and with the blade set at a steeper angle to the haft is employed, but care should be taken in selecting the implement; if it is too light it may be less suitable for cheeling work than the ordinary *Kodali*.

DEEP CULTIVATION

Much has been made of the effect of cultivation in breaking the hard pan, a layer of finer soil particles cemented together forming a layer at a greater or lesser depth from the surface. Extensive observations indicate that such pans are of much rarer occurrence than was at one time supposed. They may occur however, and when their presence is undoubted deep hoeing may be necessary, but apart from these rare cases there appear to be no valid reasons for very deep cultivation in tea, which, especially if done with blade hoes, (as is usual), results in the cutting of innumerable roots of the tea bush.

DAMAGE TO TEA ROOTS BY DEEP CULTIVATION

The damage done to the roots of tea bush by deep cold weather cultivation and trenching has now been fully recognized. Large areas of tea in Java, Sumatra and in North-East India are yielding 1,800 lb. of tea

per acre or more, after having had no deep cultivation, and in some cases no soil stirring of any kind, for many years. The soil on these areas (of both sandy and stiff texture) appears by all practical tests to be in excellent tilth. It may however prove necessary to employ deep cultivation at occasional intervals, say 3 or 4 years, to prevent incursions of thatch grass and other deep rooted weeds from drainsides or jungle edges.

TIME FOR DEEP HOEING

The time for deep cultivation, in those cases where it is necessary, is when the soil is not too wet, but yet not so dry that it is difficult to break the soil and pulverize the clods. It is certain that deep hoeing when the soil is dry, results in subsequent harm to the bush by exposing and cutting roots at a time when all available root growth is required for transference of moisture to the bush. The deep hoe should not normally be delayed beyond the end of January, as is often done on areas which are pruned late. The ideal would be to prune the whole garden (without cleaning out) as soon as possible in the cold weather, following the pruning immediately with a deep hoe. Cleaning out of unproductive and dead wood may then be carried out subsequently as time permits. This is referred to in greater detail in the chapter on pruning.

TRENCHING

At one time trenching was recommended as a means of breaking a strata or "pan" of hard soil a foot or more below the surface. Dr. Mann drew special attention to this in his report on Tea Soils; urging the necessity of getting deep enough to break through the hard pan which was supposed to be immediately below the usual depth of cultivation, especially on low-lying lands, and which formed an almost impassable barrier to drainage from above and capillary attraction from below, while at the same time resisting all attempts of the tea roots to penetrate to a sufficient depth.

Little or no evidence has been obtained of pans occurring in normal tea soils, and experiments on trenching both in Assam and in the Dooars have yielded negative results. In fact, practical experience and experimental evidence alike, indicate that little but harm generally results from trenching.

CLEAN WEEDING

Another form of weed suppression during the rains which has been tried in the plains of North-East India is clean weeding. Weeds are removed by hand, or with the aid of a small hand fork if the soil is very dry; weeds are removed and piled in heaps on adjoining roads or drain sides, and returned when rotted, to the soil, when they form valuable manure. Clean weeding is a very efficient means of weed suppression, but is expensive in its initial stages. As however weeds are removed and not merely turned in green, they have no opportunity of coming up again. Furthermore the hard surface of soil left by continued non-disturbance of the soil offers a poor germinating bed for jungle seeds. Clean weeded areas become in time noticeably less susceptible to jungle growth and one or two rounds of weeding per annum are all that is necessary to maintain a clean area.

IMPLEMENTS

The use of the flat blade hoe (the common Kodali) is very general in Assam, Cachar and Sylhet both for light and deep hoeing, but in the Dooars, Darjeeling and Terai, on stony areas at any rate, the fork hoe is much the more common. There is less risk of cutting tea roots with the fork hoe especially in deep hoeing, but on sandier soils certainly, the blade hoe is more efficient as a means of burying weeds.

FORKING, KURPYING OR THULLYING

Deep and light hoeing, and cheeling, suppress weeds in between bushes and rows of bushes but do not

remove weeds growing close to the collar of the bushes. Removal of these weeds by forking out, probably not more frequently than once a year, is necessary to prevent them from growing up into the bush and interfering with plucking. Forking round the bush also has the effect of loosening the soil which would normally be undisturbed. This soil may harbour the pupæ of insects harmful to tea, and forking detaches them from a snug contact with the soil particles, exposing many of them to the effect of the sun, and thereby destroying them. It should however be realized that forking round the bush cannot take the place of cheeling or weeding. The feeding roots of the tea bushes extend into the spaces between the bushs, and it is on these spaces that weed suppression is so essential in order that the bush may get its maximum nourishment.

CULTIVATION OF YOUNG TEA

On young replanted tea, cultivation to maintain a clean soil is essential. Jungle must on no account be allowed to grow up around the young plants. Some planters have a mistaken idea that a little jungle forms a protection to the plant from the sun, and is thus beneficial. There can be no effective shade from the jungle unless it overtops the seedlings, and if this is allowed, the jungle, being the more hardy, takes all the nourishment which is going and thus more or less chokes the tea. The young plant must be kept free of all weeds. A large implement, such as a hoe or a large fork, must on no account be allowed near young seedlings because the coolie is almost certain to put it in too deeply, and the tender roots are violently disturbed before they have got a good grip of the soil, the result being a heavy mortality.

KILLING OF YOUNG PLANTS BY CULTIVATION

This is often the cause of the failure or partial failure of extensions; the plants are literally killed with kindness, and what was meant for their nourishment becomes

their destruction. The mortality from this cause is not apparent at the time. The plants which are killed by the digging people remain green for a few days, just as a branch which is cut off and stuck into the ground would remain green for a certain length of time; hence the effect is only noticed after a time, and is not traced to its real cause.

Suppression of weeds between plants may be done by cheeling or by a careful light hoe, but hand weeding should be done for a space of 18 inches round the collar of the plant. On level areas, where the position of drains and shade trees render it practicable, cultivation of young tea for the first year or two may be done very effectively and at the same time cheaply, by cultivation with a machine of the "spring-tine harrow" pattern drawn by a buffalo. As soon as the bushes begin to form a spread however, it is necessary to discontinue this method of cultivation, otherwise damage to the sides of the bushes will occur.

HILL CULTURE

The foregoing observations are mainly concerned with cultivation of more or less level areas of tea. If the system of cultivation for level ground is important, that for steep hill-sides must be of vastly greater importance, because mistaken methods or wanton carelessness can and do work incalculable mischief, even to the extent of utterly ruining a valuable property.

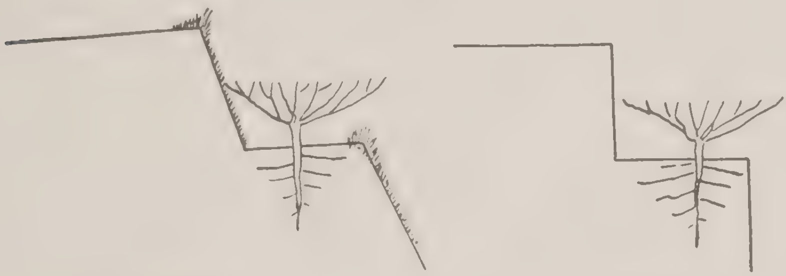
PRESERVATION OF SOIL

Naturally with steep land, the first consideration is to preserve the soil from being carried down the hill-side, and the whole system of cultivation must at all times keep this end in view.

TERRACING

On steep slopes, terracing is essential if rapid loss of surface soil is to be avoided. Terraces should follow

the contours of the slope and should not be too prominent, since they are liable to break away if cut with vertical sides. The upper surface of the terrace may slope very slightly into the hill-side to prevent wash from one terrace to the one below. Bushes should be planted in the middle of the terrace, or slightly nearer the back of the terrace, but never near the edge of the terrace, or they will suffer from drought in the dry period of the year. The diagram below illustrates the right and wrong methods of terracing.



Correct. Incorrect.

Fig. 1.—Terracing of Slopes.

To assist in prevention of wash, and damage to the edges of terraces, grass may be allowed to grow along the edges and sides of the terraces. The grass should be sickled when necessary, and should be prevented from encroaching on to the cultivated surface of the terraces.

On slopes of very stony nature, stones may with advantage be used to face the sloping sides of the terraces and thus to assist in preventing the breaking away of these sides and exposure of the roots of the tea bushes.

LIGHT FORKING

One really good digging is all the deep cultivation necessary for steep land for a whole year. The weeds which have been buried take time to rot, and they keep the soil in a comparatively free state, and if the surface is kept free of bad weeds the tea plant will thrive very well. If prunings have still to be buried, or if a light crop of jungle comes on as a result of spring rain, one or two

light forkings may be given with advantage, but as soon as the time for heavy rain draws near, all digging must be absolutely stopped, except on practically level ground, and the system of rains culture inaugurated and continued until the heavy rains are over, say the beginning or the middle of September.

GARDENS FLOWING AWAY

It is a strange fact that some planters do keep on digging steep land throughout the wet season, partly because certain other people do it, and partly in order to force their bushes to yield a little more leaf. At such seasons one has only to glance at the streams flowing down the hill-side, and with the aid of a little reflection will see that the garden itself is flowing away. The streams are thick and turgid and are coloured with the life-blood of the soil. The portion of it which is in a soluble state, and ready to be sucked in as nourishment by the tea plant, is being swept away by the flood and is thus gone for ever, leaving only the hard sand or shale, which will take years or ages of preparation before it will be rendered fit for the support of plant life.

This is not a mere fanciful picture. There are gardens in some of the hill districts, which at this moment are absolutely ruined, great portions of them being now incapable of producing more than one or two maunds of tea per acre: many of the bushes standing with their roots exposed like the legs of a crab, their unhappy bodies being withered and shrivelled and sickly because there is no nourishment left for them in the ground.

ACTUAL LOSS

The question has sometimes been asked What particular constituents are most liable to be carried away by surface wash? The first and most important is undoubtedly nitrogen in the form of nitrates, as prepared by bacterial action for plant assimilation. Another material which may be noticed is organic matter, or

humus in process of decomposition which is readily carried away along with finer soil particles by a flood of rain. Potash, phosphoric acid, etc., and other manurial constituents are also carried away, being mainly contained in the soil solution or the clay fraction of the soil.

Silica or sand of which the large particles are composed is the only material which is not readily carried off by wash. Anyone may observe this if he examines cultivated land immediately after a heavy downpour of rain. It is seen that the surface of the ground is covered with a layer of comparatively clean sand, from which the soluble constituents already mentioned, have disappeared; and the water which flowed over the surface of the ground into surface drains carried a large proportion of these substances with it. The sand acts to some extent as a protection against the further wash, so that the actual loss is chiefly that portion of soluble soil exposed on the surface. When the rainfall is very heavy, even the sand is liable to be carried away, if unprotected by something growing in it.

The important point to note is that every time steep land is dug during wet weather, a new part of the soil becomes exposed to the onslaught of rain, and a new loss of valuable constituents is inevitable.

It is impossible to cultivate land on the hill-sides, and at the same time to keep the original soil absolutely intact, yet it is possible to arrange the system and manner of cultivation in such a way that the annual loss of soil will be at a minimum, and will be made up for by the gradual decomposition of the mineral or hard constituents of the land, a process which is going on all the time, and is of course accelerated by cultivation.

RAINS CULTIVATION

Although on the approach of the rains all digging has to be stopped, the idea of weed suppression is not to be abandoned. Light weeds are normally allowed to grow to a certain height but long before they get

so tall as to impede plucking of the tea, they should be either hand-weeded or cut down by the sickle. The latter plan is probably the more common, and on unterraced slopes is probably the better, because the stumps of the weeds form an excellent check upon wash, and they form something like a filter for retaining any soil which might become detached by the onslaught of heavy rain or the heavy drippings from branches.

On steep slopes well terraced, or on gentler slopes, contour planted and bunded, clean or selective weeding is the more effective treatment as far as soil is concerned.

SELECTIVE WEEDING

Selective weeding means the weeding out of certain undesirable types of weed, e.g., deep rooting weeds, grasses and ferns, while leaving those weeds which are of a leguminous type, or are very shallow rooting and also do not grow to a height of more than a few inches. These weeds are least liable to affect the growth of the tea bush adversely, while at the same time their presence hinders surface-soil wash. It is of course essential that the labourer employed on this work understands thoroughly what is required of him, and what types of weed he must spare. Sickling is a most inefficient form of weed suppression since the undesirable types of weed even when cut are still growing and doing almost as much harm as if their growth above ground were undisturbed.

RANK WEEDS

There are certain kinds of weeds which grow so rankly as to have a very pernicious effect upon the tea. These must not only be uprooted, they must be exterminated whenever they appear. Natives of different districts have their own names for these weeds, but the more important may perhaps be distinguished as thatch or seroo, khurika, ferns, or oonia, dhoria, dhotesara, amlissa, kara (of sorts), manæ, etc. All these grow with

remarkable rapidity in good soil, and almost invariably make their appearance on land which has recently been top-dressed or manured with dung. If uprooted and left on the ground during the rains, they just take root again on the surface and are soon growing as gaily as before. It is of great importance that they be removed before they flower and shed their seed, otherwise the following season will see a much larger crop spring up.

The only way to deal successfully with these weeds is to uproot them, and to have a separate gang to collect them into baskets and carry them off the cultivation. If this is done while the weeds are quite young and small, it entails very little extra labour. A good way to dispose of them, if labour is available, is to allow them to dry out and then to compost them or to allow them to rot in heaps adjacent to the areas. When rotted they can with safety be returned to the soil. The most difficult weed to eradicate on a hill garden is seroo, thatch, or sun grass. It is a comparatively easy matter on the plains, where it is destroyed by frequent hoeing in the dry weather, or better still by forking and removing as much of the root growth as possible; but on a hill garden the digging cannot be frequent, and is usually just enough to encourage and cultivate it. A separate gang of coolies has to be detailed for this work in the digging season, all the thatch grass roots being taken out and subsequently carried off. Terraces and revetments must be dug down in order to do this work properly, but they can be gradually made up again during the following season. After this has been done, a few ends of roots which may have escaped notice and remain in the ground will sprout up when the rains come on, but if these are at once pulled out by hand, the last traces of the enemy will disappear.

FERNS

Ferns have a knack of lodging themselves at the collars of the bushes, and are specially troublesome in China bushes with their many stems. They are easily

removed by means of a steel hook, and must be carried off as described above. A very common mode of dealing with ferns is to have them carefully taken out in the cold weather, and placed on the tops of the tea bushes, where the sun dries them up, and they soon die. Planters who do this, however, wonder why it is that they have to do the same thing every year, and the ferns always appear again. The secret is that when they are placed on the bushes to dry, the sun ripens their seed, which drops into the centre of the bush, a perfect situation for it, and so a new crop is sown for the coming season. Ferns should not on any account be left on the tops of the bushes.

JUNGLE SEEDS

When overseers are marking the spot when coolies begin work in the morning, it is customary to do this with strips of jungle or tall grass, and they are very fond of bringing for this purpose any kind of grass which is in flower, it looks so nice when stuck into a tea bush. They do not, however, realize that the flower means seed, and the seed means jungle of a pernicious kind being propagated amongst the tea.

REVETMENTS

In the slack season, spare labour can be advantageously employed at building revetments to support roads or terraces in the tea, especially in making terraces at intervals to prevent wash, and in building the upper bank of roadsides, when the soil has gradually got worn away, and roots more or less exposed. At such seasons also all roads can be repaired, and short cuts built with stone so as to form permanent paths for ready access of the coolies to all parts of the cultivation.

CHAPTER II

DRAINAGE

It is a well-established fact that tea cannot thrive in a waterlogged soil, or in one which is subject to frequent and lengthy periods of flooding. The harmful effect of prolonged dry spells, resulting in a low water content of the soil, is equally well recognized.

OPTIMUM SOIL MOISTURE CONTENT

Some plants, however, like the water hyacinth, thrive best under waterlogged conditions, while at the opposite extreme certain grasses grow best in very dry soils. It is now recognized that for every type of plant there is an optimum soil-water content, or that amount of water which is most favourable to the health and growth of that particular type of plant, the optimum soil moisture content varies according to the type of soil on which the plant is grown. On a very sandy soil, the optimum moisture content is about 15 per cent for tea; on a good loam, 18 to 20 per cent, while on a very stiff clay soil the moisture content at which tea would grow best might be as high as 25 per cent or more.

PRIMARY OBJECT OF DRAINAGE

The primary object of drainage operations is as far as possible to maintain the soil at its optimum water content for as long a period as possible throughout the year. Care is necessary in designing a drainage scheme, to ensure that while it may effectively remove excess water during the period of high rainfall, it does not result in excessive drying out of the soil during the period of low rainfall.

Formerly, theory and practice on drainage were bound up with the idea that all rainfall must be made

to pass through the soil. It was supposed that the soil could be regarded as a gigantic filter, through which water could pass readily, and that the rain water contained a large store of valuable plant food which it gave up to the soil in passing through it. While it is true that water will percolate through soil, its rate of percolation is very slow in all but the sandiest soils, and even in these soils, water will pass only if there is a head of standing water on the surface of the soil. As soon as this has gone into the soil, no further percolation takes place, though the soil is itself completely saturated.

PASSAGE OF WATER THROUGH SOILS

The movement of water through soils of different types is readily demonstrated in the following manner. Moist soil is packed into a tube or pipe about two feet long, with a bore of $1\frac{1}{2}$ inches or more diameter. One end is plugged with cotton-wool to prevent the soil from falling out. The tube is placed in a vertical position and water is poured into the tube, on top of the column of soil, until water begins to trickle through at the bottom. This may take a considerable time—days in fact, in the case of a stiff soil. After allowing the soil to drain till no more water trickles out, it will be found that the soil in the tube is still saturated with water, or waterlogged. However long we leave the soil, no more water will drain out, and the soil will continue to remain waterlogged (provided, of course, water is prevented from drying out at the top surface of the soil, by covering the upper end of the tube with a piece of cloth or paper). A saturated or waterlogged soil does not therefore dry out by downward percolation of the water; and it can be similarly shown that water does not drain sideways from a saturated soil. The only manner in which a saturated or waterlogged soil can lose its excess of water is by drying out under the influence of sun and breeze. Percolation takes place only under a head of water, and a fairly sandy soil when saturated, will allow 2 inches of water to percolate through 2 feet in an hour or two. With a stiff clay soil,

it may take days or weeks for the same amount of water to pass through a similar depth of soil.

If then we regard the soil as a filter, and force all rainfall to pass through it, we are bound to get, after a continued spell of heavy rain, conditions of waterlogging from which the tea bush can be rescued only by a dry sunny spell. Areas on which some provision is not made for rapid removal of water in periods of heavy rainfall, are likely to remain waterlogged for the greater part of the rainy season.

PLANT FOOD IN RAIN WATER—LOSS OF PLANT FOOD BY LEACHING

An important reason given for ensuring that as much of the rainfall as possible shall pass through the soil, was that the rain contains a valuable store of plant food, which it gives up to the soil, in passing through it. This plant food is nitrogen in the form of soluble nitrate and ammonia, dissolved out of the atmosphere by the falling rain. The quantity of nitrogen supplied by this source has been estimated at 3 to 5 lb. per acre annually at Rothamsted in England and at 6 to 7 lb. per acre in America at a place where the annual rainfall is about 40 inches. In tea districts, where rainfall varies commonly between 75 inches and 150 inches, the amount of nitrogen supplied might be between 12 and 24 lb. per acre per annum. If all this quantity of available nitrogen were given up to the soil, it would assist greatly to maintain soil fertility. Unfortunately, however, rain water passing through a soil leaches out plant food from the soil, and the loss of available nitrogen (nitrates) due to leaching are estimated to be very considerable—greater in fact than the available nitrogen likely to be added to the soil by the rain water.

In periods of heavy rain, then, the problem is the removal of much of the rainfall before it soaks into the soil. Also low-lying land must be protected from waterlogging by surface wash from higher land. These two

problems constitute what is perhaps the most important aspect of drainage of tea soils.

CONTROL OF SURFACE WASH

The task of removal of surface water must be accomplished with the minimum loss of soil. On level land there is little risk of soil wash, except near the edges of drains. This can be avoided by keeping a strip of unhoed soil along the drainside. Any unduly rapid flow of surface water is thus temporarily checked, suspended soil is deposited and water alone filters into the drain. The leaving of the unhoed strip also assists greatly in preventing drainsides from falling in and is especially valuable on lighter soils. The jungle growth on the unhoed strip will of course require sickling occasionally.

On slopes, surface wash may be prevented by low "*bunds*" running at intervals across the slope, or along the contours. The steeper the slope, the closer naturally will the *bunds* be placed. In extreme cases, the only way to avoid soil wash is the terracing of slopes. A contour drain on sloping land should have a bund running along its upper side. Green crops such as *boga medeloa* and *arhar* dal planted in lines along contours or across slopes, help to prevent soil wash and are very useful for this purpose in the case of young replanted tea on sloping land.

The presence of a broadcast green crop or of weeds hinders natural run off, and at times, when rainfall is heavy, the presence of broadcast green crops or weed may help to waterlog a soil.

SIZE AND NUMBER OF SURFACE WATER DRAINS

The size and number of drains for removal of surface water naturally varies according to the type of soil, the lie of land and the amount of rainfall to be dealt with. In sandy soils percolation under a head of water may be fairly rapid so that less surface water has to be dealt with on sandy than on clay soils, other conditions being equal.

Sandy soils do not therefore require to be close drained; in fact too many drains may do harm, by increasing the amount of drying out during the seasons of short rainfall. In general, where surface water drains are necessary, 50 to 80 feet apart are suitable limits on sandy soils and sandy loams.

On clay soils, drains may need to be close, but no useful purpose is served by making them deep, since percolation on clay soils, even under a head of water, is extremely slow. Shallow drains, not deeper than 2 feet, and at intervals of 20 to 40 feet apart, are generally necessary on clays and clay loams, to ensure rapid removal of excess water. Main drains will of course need to be of sufficient size and depth to carry off water rapidly from the subsidiary drains, so that no backing up of water occurs after heavy showers.

Since percolation on any type of soil is very slow except under a definite head of water, it is of little or no value to cut drains through low-lying waterlogged land, in the hope of allowing water to escape. Contour drains must be placed in such a way as to prevent excess water from higher areas from coming on to the low-lying area.

SUBSOIL WATER

So far we have dealt only with surface water; there is however the problem of subsoil water which frequently is of great importance in regulating root growth and water supply to the plant during the dry season. This involves a consideration of the water table, and of the force known as "capillary attraction".

CAPILLARY ATTRACTION

The principal reason why land does not become dried up by drainage is to be found in the natural law named "Capillary Attraction". An everyday illustration of this can be seen in using a piece of blotting paper to lick up a blot of ink. Just as ink rises up into the blotting paper so the moisture rises up from the lower layers of

soil to replace water removed by evaporation, provided the soil is in a healthy state. In this connection certain experiments were made some years ago by Professor Wrightson, with a series of glass tubes filled with different classes of soil. The lower end of each tube was placed in water. The results were recorded thus: "Twenty minutes after the experiment was commenced the fine sand was wet nine inches above the level of the water in the saucers; and seven hours after, it was wet fifteen inches up the tube. Clay, in a finely powdered state, had during this time only raised water three and five inches in height, taking two tubes containing similar soils. The capillary power of the sand was, however, almost exhausted in this short period, and although the experiment was conducted for 132 days the column of water was never raised higher than 23 inches. The clay behaved very differently. Although water rose slowly, it rose very steadily, and at the termination of the experiment, 132 days after its commencement, it was wet 35 and 33 inches, taking again the results of two tubes."

It is thus seen that capillarity is most active in sandy soil, but it affects a much wider range in clay soil. Actually a heavy clay will raise water as much as 28 feet above the water level, but so slowly that in practice a plant on a very stiff soil may get no assistance, in time of severe drought, from subsoil water.

WATER TABLE

The water table, or water level, is that level below the surface of the soil, at which the soil is completely saturated with water. A well from which no water had been recently drawn, would indicate the water table in that particular spot, by the height of the water in the well.

The water table varies with season, being highest at the end of the rains and lowest at the end of the dry weather. If the water table is sufficiently near the surface it may play a very great part in regulating the moisture in the top few feet of soil occupied by the roots of the tea

bush. If we pack a tube with soil, place it vertically with the lower end dipping in water and leave it undisturbed for a sufficiently long time, a state of balance is reached, in which the soil near the water level is saturated, and the moisture content of the soil becomes less and less, as the distance above the level of the water increases. At a sufficient height above the water level the soil will be practically dry. The time taken to attain this balance or equilibrium, will vary according to the type of soil used. A sandy soil attains such equilibrium rapidly, but with a very stiff clay soil, it may take two years or more. On the other hand a clay soil remains nearly saturated for a very considerable distance above water level, often 10 or 20 feet with very stiff clays, while a sandy soil will be saturated for not more than one or two feet above water level.

It might be thought, therefore, that it would be impossible to grow tea on clay soils with water levels 10 feet or less from the surface. In practice, however, we have to reckon with another factor, evaporation of water from the surface of the soil by sun and wind. This keeps the soil reasonably dry, and upward movement of water from the water level is so slow in a clay soil that it cannot keep pace with surface evaporation. In fact, in times of severe drought, evaporation, especially in an over-drained and over-cultivated clay soil, may be so great that the subsoil water supply is practically useless in replacing losses by evaporation. Thus though drains may be necessary, their chief action is to remove surface water in periods of heavy rain, and they should not be made too deep. Deep cultivation should be avoided particularly when the soil is very dry.

As we have seen, although a sandy soil remains saturated for not more than about two feet above water level, the rise of water in such a soil is so rapid that it may easily keep pace with surface evaporation. Where the water table on a sandy soil is very high in the rains, and low in the dry season, deep drains will be necessary in order to lower the high water level, and so to encourage the roots to go down into soil which will still be reasonably

moist in dry periods of the year. On sandy soils, such deep drains need not be close, since the movement of the water level is so much more rapid in these soils.

TRANSPIRATION

Every growing plant is continually absorbing water through its roots and giving it off through its leaves. This is the process of transpiration, and since the water taken up by the roots is the medium through which the plant gets its supply of food from the soil, a check in this water supply may mean temporary starvation to the plant. The tea bush shows signs of temporary water shortage by the wilting of its leaves and by partial or complete cessation of flushing. In extreme cases, as at the end of a long drought, all green leaf and stem may die back.

Reduction in transpiration causes young leaf to lose its characteristic turgidity and to become particularly susceptible to attack by red spider.

It is essential therefore that everything possible shall be done to avoid unnecessary loss of moisture from the soil during the dry season. The presence of a green crop on the soil during the cold weather shades the soil and thus reduces evaporation of moisture, but the total moisture which is removed from the soil by transpiration of a leafy green crop is generally much greater than the moisture saved by evaporation. Hence the presence of a green crop dries the soil. This drying effect can be greatly minimized by using a green crop such as *boga medeloa* which can be kept well lopped of most of its leaves during the dry weather. Shade trees which retain a heavy foliage during the dry weather tend to dry out the soil unduly, and their harmful effect on surrounding tea at the end of a long dry period in the cold weather is almost invariably very marked.

For the same reason outlined above, a soil should be kept free of weed growth during the dry season. A clean soil, under widespread tea bushes which exert the maximum shading effect on the soil, is one which is least likely to dry out unduly. Probably for these reasons,

unpruned tea suffers less than it might be expected to do, during dry weather.

EVAPORATION

The larger the surface of soil exposed to the drying action of sun and wind, the greater the loss of soil moisture through evaporation. Drains therefore increase evaporation and should not be wider than necessary, especially on sandy soils where the effect is often very marked, as evidenced by the poorness of drainside bushes. Such operations as trenching, deep hoeing and deep forking are certain to have harmful effect if done when the soil is already below its optimum moisture content. Thus in the dry weather, over-draining, trenching and other forms of deep cultivation, presence of jungle or leafy green crop, and evergreen shade trees, all tend to reduce soil moisture, and many, on sandy soils and in droughty years, have seriously harmful effects on tea.

EFFECT OF SOIL MOISTURE ON AVAILABLE PLANT FOOD

The natural production of nitrates, which constitute the most important available plant food in the soil, is due to the action of various organisms. This natural production of nitrates from vegetable and animal residues in the soil is known as " nitrification ", and the process can go to completion only if plenty of oxygen, and a certain amount of moisture, is present . In a dry loam, for example, with a moisture content of 10 per cent or less, nitrification is very slow. It is also very slow indeed if the moisture content is above 25 per cent. Temperature, too, affects nitrification, which is slowed up greatly at low temperatures, and goes on most rapidly at about 98°F.

A waterlogged soil, therefore, in which there is excess moisture, little or no oxygen, and which is likely to be colder than a well-drained soil, provides the worst possible conditions for nitrification, and explains why growth of normal plants is poor under such conditions. As we have

previously stated, there are, it is true, plants which can live in waterlogged soils. These are called hydrophytes, and examples of this class of plants are cranberries, water-lilies and certain types of rice. These plants are probably able to absorb their nitrogen in the form of ammonia, and do not need the formation of nitrates. The opposite type of plants known as xerophytes can live under extremely dry conditions. This type includes certain grasses and cactus. The great majority of plants particularly those of economic value belong to the mesophyte group, and suffer both from excess and stortage of moisture.

METHODS OF DRAINAGE

In tea gardens, where rainfall is more or less severe, it is generally necessary to adhere to the present system of open drains so as to deal effectively with run off water in times of heavy rainfall. Underground pipe and tile drainage, besides being very expensive, is unlikely to be adopted on a large scale in tea districts where rainfall is so much heavier than in the more temperate countries.

INSTRUMENT

For undulating lands, or lands which are almost level, it is difficult to arrange a suitable system of drainage without the aid of an instrument. The eye is a deceptive guide as to just how a gentle slope goes, and it not infrequently happens that in a rough happy-go-lucky arrangement of drains an attempt has been made to induce water to flow uphill. In such cases the amateur engineer has to begin over again, and not infrequently the error has been discovered only after a considerable area has been drained at great expense: and then when heavy rain has come, it is found that some of the drains are flowing the wrong way, until they partially fill themselves with water.

DUMPY LEVEL

The instrument generally used for laying out a system of drainage is the dumpy level, but although accurate, it

is a clumsy method. Engineers have sometimes improvised instruments to take its place, by which the work can be done more rapidly. These are generally too crude, however, and are not correct.

CLINOMETER

An instrument has been invented which quite meets the want and has proved of great value as it can be operated by any intelligent person without previous training, and is remarkably accurate. It is Bald's patent clinometer, and is here illustrated.

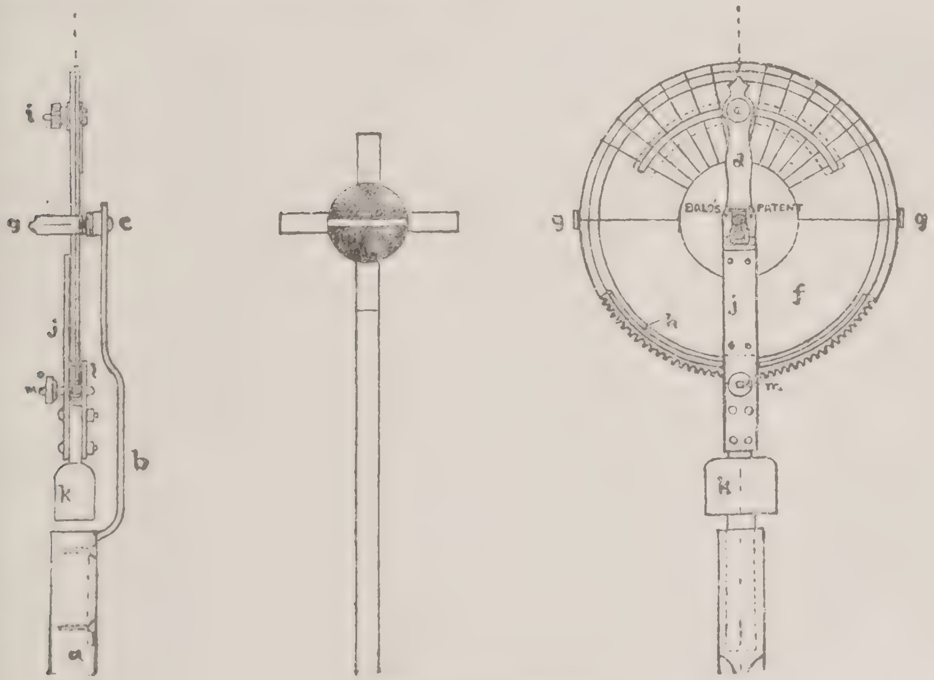


FIG. 2.—Clinometer

When opening out new land it is advisable to clear the whole block before arranging the drainage system. The main drain should then be marked out before planting or staking.

In replanting old tea areas, it will generally be found advisable to make a clean sweep of all except possibly the main drains, and to redrain the area, since many of

the old drains may be unnecessary, or in the wrong places, or wrongly graded. The filling in of old drains would of course have been done as soon as possible after uprooting the old tea.

MAIN DRAINS

The reason for surveying and fixing the lines of main drains before staking for planting is that the main drains must of necessity follow the lines of depression of the land, irrespective of how they may fit or not fit in with the lines of the planting.

It is desirable, in the first instance, to ascertain by survey the highest points on the block. This can readily be done with the instrument mentioned above, and along with the clinometer there is always supplied a slip giving instructions for the beginner.

RANGING RODS

To facilitate the work it is desirable to have several ranging rods, an attendant taking each one to a different point, so that the observer can locate his points rapidly.

After the highest points have been fixed and marked with suitable stakes and grade pegs, the observer then begins at one of these points and makes a rough survey to a suitable point of outflow. The most suitable point of delivery, or outflow, may be a stream or a low-lying piece of waste land. In going from point to point the observer will note the angle of each observation and so will be able to judge as to the definite angle to be adopted for the whole line, or part of the line. It is not necessary to carry the drain at the same slope, or gradient, all the way; but it must at least be carried at an even gradient by sections, and also to make sure that no part shall have a level stretch or an actual depression.

When lands are almost level, it is sometimes necessary to carry a main drain through waste land for a long distance, so as to debouch into a river at a low enough level to receive it.

PEGS AND STAKES—GAUGE ROD

For marking out the lines of drains it is necessary to have a supply of grade pegs and measuring stakes. The pegs may be about one foot and the stakes three feet long. It is also desirable to have a gauge rod, as illustrated. This is somewhat like the gauge which is used for measuring the height of horses, only that the arm is fixed, instead of movable. The arm is bolted or screwed to the rod; but is arranged so that it can readily be altered in a few minutes for measuring any depth of drains from two to five feet deep. The method of using it, as well as the arrangement of pegs and stakes, is shown in the diagram.

PROCEDURE

Figure 3 shows how to begin surveying the line for a main drain: the ground being shown in section. Beginning from the highest point on the ground, marked

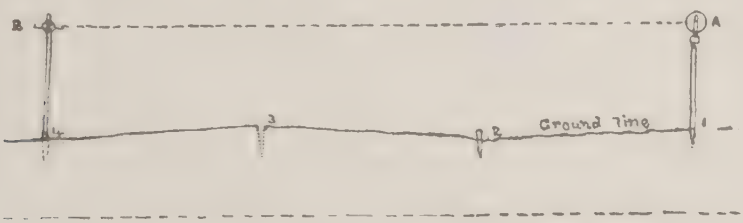


FIG. 3.—Surveying Line of Drain

"1", a peg is driven right into the ground, and the clinometer "A" placed upon it as shown. The pointer of the clinometer is arranged at the desired angle.

The ranging rod is then taken to a convenient distance, marked "4" in the diagram, where a peg is driven into the ground just far enough so that when the ranging rod is placed upon it the centre of the target comes into the line of sight through the vanes of the clinometer, as shown by the upper dotted line. Intermediate pegs may now be driven into the ground at "3" and "2", using the ranging rod as before. If the ground is

undulating, as shown in the diagram, some pegs may have to be driven below the level of the surface before the centre of the ranging rod comes into the line of sight, or line of collimation, while others may have to be kept with their heads several inches above the surface; the object being to ensure that the bottom of the drain, shown by lower dotted line, shall be throughout the length exactly at the same angle of inclination.

As the survey proceeds it may be necessary to alter slightly the angle fixed upon, more or less, but each stretch of drain two or three hundred feet long should be of uniform inclination, or gradient, throughout that portion.

The grade pegs should be inserted in the ground at regular intervals of 12 or 24 feet, or other suitable distance, so that when the work-people begin to dig the drain it may be easy to allot task or contract work.

STAKES

When digging is commenced the grade pegs will necessarily be taken up. In order to retain the survey line intact, it is necessary to drive a stake into the ground about six or eight inches away from each grade peg, outside the zone of the drain as shown in the diagram (Fig. 4), which is a cross section of the ground. The stake must be driven in so that in each case its head will be exactly two feet higher than the head of the grade peg.

The methods of measuring the depth of the drain, as the work of digging proceeds, is shown in the diagram. The gauge rod now comes into use, as shown. The operative must dig down until the arm of the gauge rod can touch the top of the stake.

MEASURING

When measuring a four feet drain the arm of the gauge rod is fixed at six feet from the lower end, thus allowing for the extra two feet of stake above the original height of the grade peg. The stake being fixed an extra

two feet high allows for the soil dug up being placed anywhere without disturbing the line of survey.

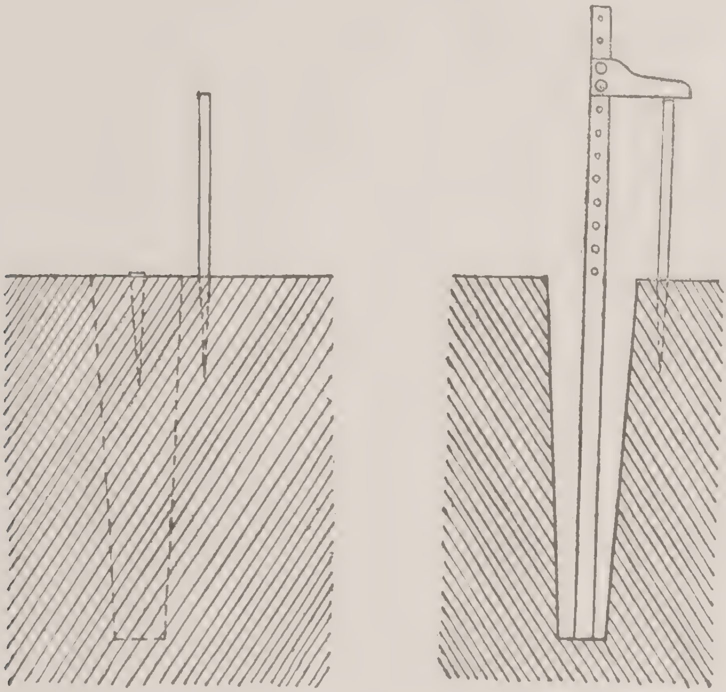


FIG. 4.—Measuring Depth of Drain

MINOR DRAINS

Minor drains will be surveyed and operated in the same way as described above, the surveying being done from the highest point, and the digging commenced from the lowest point.

BUILDING

Some protection may be necessary at the outlet of main drains. This can be a wall of brick or stone, whichever may be available. Whenever there is a bend in a main drain the side of the drain which receives the impact of the flow should also be built up.

DIMENSIONS

The sides of the drains should be as steep as the nature of the soil will allow without falling in, and the width of the main drains such that they can be periodically cleared out with an ordinary hoe. The minor drains can be even narrower than those shown in the diagrams, and may be only four inches wide at the bottom, the object being to have as little as possible of the sides exposed to the drying action of sunshine during seasons of drought. The narrow drains can be dug with the four inch trenching hoe.

GRADIENT—DEAD LEVEL

The gradient of drains is also controlled to a great extent by the gradient possible on the block of land. Engineers point out that some rivers flow with a fall of only three inches per mile in certain places. This must of course be after making allowance for the curvature of the earth, because water does not lie on a dead level. The surface of the sea, for instance, is globular, and falls away from the dead level as much as eight inches in one mile.

In some circumstances drain pipes have been laid at a fall of one in a thousand feet; but water can flow in the smooth interior of a pipe much more readily than on a soil bottom. About one in 300 is quite practicable. If the drains flow very steeply there is great danger of scouring.

STEEP DRAINS

This is of the greatest importance where the surface soil is very soft, such as the volcanic soils of the islands in or near the Straits of Malacca, Java, etc. There are some rubber estates in the Federated Malay States where injudiciously laid out drains accomplished considerable havoc years ago.

GRIDIRON—HERRING BONE

The plan or scheme of drainage may be different to suit circumstances in each case. What is termed the "Gridiron" system is an arrangement whereby the minor drains fall into main drains from one side only. The "Herring Bone" system is the most common, the minor drains falling into the main drains from both sides, at an angle in the direction of the flow. If the fall is considerable, the minor drains should enter the main opposite each other ; but if the fall is very slight they should enter alternately, as it has been found in actual practice that when opposite they tend to cause a back-wash in the main drain, and a check to the current.

HILL DRAINAGE

For hill plantations the problem of drainage is much more simple. As a general rule the main drains already exist in the from of mountain streams, and the minor drains only have to be constructed. These must follow the contour of each hill, or spur, at a gradient of not more than one or two degrees, the alignment always to be made with the aid of a suitable instrument. On most hill estates, however, there are some flats or hollows which carry very good soil, but which suffer from excessive wetness resulting from underground springs. The draining of these plots is imperative, if the best use is to be made of the land for cultivation of any kind. In many such cases the principal difficulty is caused by land crabs, which persistently block up the water channels leading to open drains, and break down the sides of the drains, rendering them ineffective. The only way to make proper drains in such cases is to build them throughout with stone.

CLEANING DRAINS

When drains are cleaned out and deepened, or when new drains are being made, it is essential that the soil taken out, be spread out well over the surrounding

area and not piled thickly in the first row or two of tea alongside the drain. A plant suffers if subsoil containing little or no plant food or nitrifying organisms is heaped round its collar.

It is seldom that any large area of tea can be considered to require no drains at all. If the soil is very permeable, the water table deep, and there is a good natural run off, further drainage is probably unnecessary. It is unlikely however that a very large area with such natural advantages will occur, since there are generally depressions and pockets which need local contour drainage, or bunds to prevent them from becoming waterlogged.

SPECIAL CASES OF DRAINAGE ON TEA GARDENS

Long gentle slopes such as occur, for example, on gardens at the foot of hills, generally require catch drains, even if the soil is sandy, to prevent excessive wetness of the lower slopes due to run off and seepage from the higher land. The steeper slopes of hill gardens, and gardens such as those of Cachar and Sylhet containing "teelas", require terraces or "bunds" to check rapid run off and so to prevent soil erosion. Some drainage is also usually necessary, especially on the stiffer soils, to prevent over-wetness of the lower slopes. Drains, as well as terraces and bunds, would, of course, be contoured.

DRAINING OF PEAT BHEELS

The peat bheels of the Surma Valley require close shallow drains to carry water away quickly after heavy storms. Bheel soils deteriorate if dried out by deep drains, while the tea bush never needs a deep-rooting system on such a soil. Much can be done to prevent over-wetness of bheels, by contour draining the surrounding teela slopes. A contour drain about four feet deep running round the perimeter of the bheel is what is required.

This contour drain should not be actually on the flat itself, but a few yards up the slope, and will most probably be found to obviate the need for very close drains on the bheel or flat.

In certain districts, as for example the Eastern Dooars, much tea is put out on sandy soils overlying very pervious stony subsoils. It is often sufficient on such areas where the water table is deep to drain into the subsoil by three feet drains with no outlets. No actual water carrying drains are necessary in such cases.

A garden with a high water table needs deep drains, to lower the water table and to carry the excess water off the tea area. On areas which are often subject to flooding, the drainage system, while often unable to prevent such flooding, should be designed to remove water as soon as possible after the flood has subsided. Care must be taken, however, not to drain into a river or bheel which is in the habit of frequently backing up and causing flooding, unless such drainage is combined with a system of sluices and protection works for use in flood time.

CHAPTER III

PRUNING

REASONS

In its natural state in the forest the tea shrub grows to a height of from 15 to 30 feet or more, a height and an extent of foliage which unfits it for rapid production of leaves in successive "flushes", while its shape, as well as height, would render the labour of gathering the leaves both difficult and expensive. Hence the primary object of pruning is to change the form which the plant would naturally take, and so turn it into a low bush instead of a tree.

The next object is to encourage the bush to produce leaves rather than wood, and to spread into a ramification of twigs, giving a large plucking surface, and yet not so dense as to obstruct the free passage of light and air to the leaves everywhere, which is a condition essential to the healthy life of the plant.

As the plant matures and ages, it becomes necessary to remove dead and moribund branches, and to thin out unproductive shoots where growth has become too dense.

In all questions of pruning, as well as other operations, the continued robust health of the plant must be reckoned as of primary importance, and when properly done, pruning can be a distinct aid rather than a hindrance to health. It has been observed, for instance, that in the case of tea plants grown for ornament those which were pruned occasionally kept in better health than others which were allowed to grow naturally and to retain dead and diseased wood.

On the other hand it has been shown by experiments on fruit trees, that the more severely the young plant is pruned by the removal of healthy but unwanted

growth, the more restricted is the ultimate size of the mature tree. It is more than likely that too severe pruning in early years may result in a permanent stunting of the tea bush by the time it becomes mature.

AGE FOR FIRST PRUNING

The age at which pruning of the young plant should commence has been much discussed. Some people think it desirable to let the plant grow for two or three years and attain a height of six feet or more before pruning, the theory being that no check should be given to its development until the plant has become big and strong. The chief objection to this is that, with some types of plant, there appears to be a tendency to grow a long clean stem, and after this has been formed, there is difficulty in forcing the plant to throw out branches anywhere near the ground, so as to become bushy. The effect of successive severe prunings in order to accomplish this is much more severe than if the operation had been performed when the plant was quite young and succulent, and when the bark of the stem still contained the eyes in embryo, from which new branches could be developed; hence it has been found much better to prune when quite young, one year, or eighteen months from planting.

PRUNING OF YOUNG TEA

There are many methods in vogue for pruning young tea plants. It is held by some planters that the best results are obtained by cutting the plant down to 2 inches from the ground in the first pruning; then to 9 or 10 inches in the second, leaving side branches. Others prefer the first cut to be at 4 inches from the ground, others again at 6 inches for plants with no branching below this height, and at 10 or 12 inches in the case of plants which branch at or below 6 inches from the ground. Very successful results have been obtained in recent years by much less drastic pruning in the early stages, and where comparisons are provided their results favour the less drastic pruning methods.

A system which has been employed with great success is as follows:—

1st year after planting. The plant is decentred by removing the centre growing stem, flush with a side branch, at 8 to 12 inches from the ground, so as to leave two (or more if possible) side branches, which are headed back to 18 or 20 inches if necessary. The pruning is done in November and plants are tipped at 30 inches from the ground during the following season.

2nd year after planting. Plants are left unpruned and tipped at 34 to 36 inches.

3rd year after planting. Plants are pruned flat across at 20 inches removing any strong growing centre shoot, flush with a side branch.

4th and following years. Prune to leave half an inch of new wood.

YOUNG TEA UNPRUNED

The purpose of leaving the plant unpruned in its second year after planting is that, by leaving the young bush unpruned, the root system is encouraged to extend. There is no doubt that larger and stronger bushes do result from leaving unpruned, compared with pruning again in the second year after planting.

SINGLE STEM PLANTS

The old objection to the single stem type of plant, the cabbage stem, or wineglass stem type, which does not branch from ground level, has largely disappeared nowadays. Provided the single stem is not too high, i.e., not more than say 12 to 15 inches from the ground, subsequent medium pruning of such a bush presents no difficulty, while a single stem bush is less likely to be damaged by the hoeing men, and is easier to keep clean round its collar. Moreover the risk of wood rotting diseases entering through pruning cuts near the collar, and spreading down into the root, is entirely eliminated.

Young tea pruned as described above not only comes into bearing more quickly, but also covers the ground more quickly, and reduces cultivation costs.

The problem of single stem plants which do not carry two or more branches below about 10 inches from the ground, still remains an unsettled one. Whether the cut is made at 2 inches from the ground, at 4 inches or at 6 inches, the new growth frequently comes from not higher than one to one and a half inches from the collar. This results in a plant with a piece of dead central stem, which is impossible, or at best very difficult to remove without damaging the side shoots. Such a piece of dead wood may, with luck, be eaten by white ants before wood rotting disease gets in and spreads down into the collar. Frequently the disease gets there first and though the bush may live for many years, it may never become a "16 anna" bush, and often dies prematurely and has to be infilled.

There is no logical reason why a single stem plant should not be cut at say 12 inches from the ground. If it throws side shoots only from near the collar, the position is no worse than if the plant had been cut to 2 inches, 4 inches, or 6 inches. On the other hand, there is a chance that shoots may come from, say, 6½, 8 and 9 inches, in which case after cutting out the top 3 inches of centre stem, we are left with a sound, branching plant with *no dead snag in the centre*.

Single stemmers cut to 12 inches should not be left to grow untouched during the following year. By leaving them to grow untouched, there is every chance that a single shoot will start from just below the 12 inches cut, and if this shoot is allowed to grow unchecked there is little chance of other side shoots starting from below it on the main stem. If the top leading shoot is headed back, by tipping regularly at 28 or 30 inches there is a much better chance of shoots developing lower on the main stem, and so forming a balanced, low-branching plant.

TIME FOR PRUNING YOUNG TEA

In the case of young tea, and mature tea which is cut back, the time of the year when the pruning is done is of great importance. The leaves of the bush are the factories in which the raw materials, nitrates, etc., from the soil, and carbonic acid from the air, are built up into the complex substances which form new growth. It might therefore be thought that complete removal of all leaf from a bush would cause the bush to die, and this is true under certain circumstances. In the case of a healthy bush, however, part of the plant

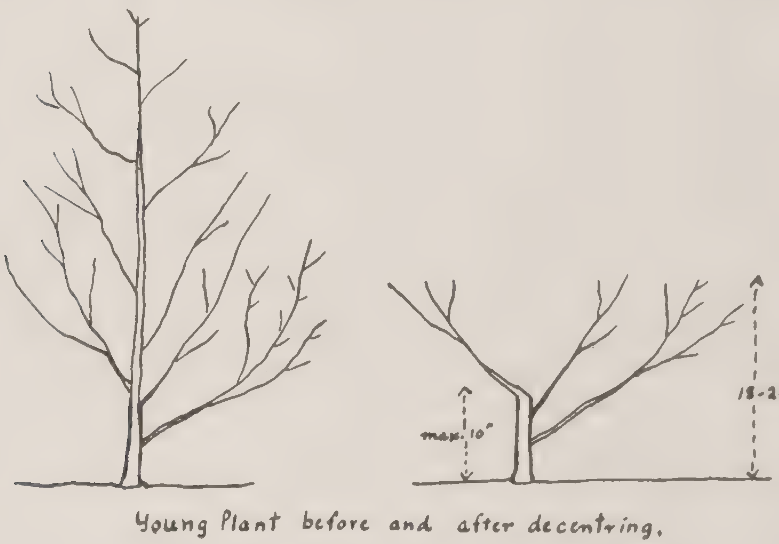


FIG. 5. Pruning of Young Tea.

food manufactured in the leaves is stored up as reserve in roots and frame. While the bush is flushing vigorously and being plucked, there is little chance for the storage of reserves. During the non-growing season, however, and at the end of a "banjhi" or resting period in the growing season, reserves are stored up, to be partly or entirely used up again when vigorous flushing recommences.

If we remove all the leaves from a bush during the period when reserves are low, i.e., April to October,

there is a risk of weakening the bush severely, or even of killing it, since it is left after defoliating with neither reserve of food nor the means of manufacturing it.

When young tea is pruned, perhaps not all but at any rate a large proportion of the leaf area is removed and it is obviously important that this should be done when reserves are at a maximum: this will be from November to February or March. An experiment in Assam on the time of pruning young tea showed that February pruning resulted in a lower percentage of deaths than June pruning. This was in a year of exceptional drought up to the middle of May.

NO ELONGATION OF YOUNG WOOD

It used to be thought, and the impression is still held by many planters, that young wood elongates for several years after pruning. Thus, the centre stem of a plant which is cut at an eye or side branch 8 inches from the ground will become 10 or 12 inches in length after a few years. This is decidedly not the case, however; in fact if such a case of elongation could be authentically proved, it would be a matter of excitement in botanical circles! If two marks are made on the stem of any plant—say 1 foot apart—these marks will be within a very small variation indeed, still 1 foot apart after many years.

What has actually happened on tea gardens, in many cases, is that soil wash has occurred, and the level of the soil has been lowered by two or three or more inches, thus making it appear that the stem of the plant has elongated. With modern methods for prevention of soil wash, however, such apparent elongation is not likely to occur.

TOP PRUNING

After the young plant has been four or five years in the ground, and has been pruned judiciously, its frame will be formed, sound and well balanced. Subsequent

pruning methods will depend to a great extent on climatic and economic conditions, compatible with maintaining a sound, healthy and steady yielding bush. In some plains districts, as for example in Upper Assam where quality is of primary importance, pruning methods must be very different from those in districts where low cost of production is the main consideration involving a high yield per acre of tea of the type described as "common".

Frequency of pruning, whether annual, biennial, or at longer intervals, and the amount of growth removed in pruning, are the two factors in pruning which chiefly influence crop and quality.

FREQUENCY OF PRUNING

The frequency of pruning depends to some extent upon circumstances, and experience has proved that in forcing climates, where a large yield is obtained, the best results are obtained by pruning once a year. In Ceylon, where there is no winter or season of rest, some of the best authorities, while recommending an annual pruning for tea at low elevations, prefer to leave hill gardens unpruned for two or even three or more years, if at a high altitude.

UNPRUNED TEA

In North India the practice generally has been to prune the whole estate annually, during the season of plant inactivity. On hill gardens also, this was almost invariably the custom in past years. In more recent years, however, opinions on this subject have become greatly modified, and it is generally agreed that an annual pruning is in some instances too frequent. For estates at an elevation over 4,000 feet it is distinctly advantageous to leave one-half, or even two-thirds, of the area unpruned each year.

On the majority of high-elevation gardens in Darjeeling only one-third of the whole area is pruned each year in turn. Under this system the largest crop

is obtained in the third year after pruning, and the average crop per acre for the whole estate nowadays compares very favourably with that made before this system was generally adopted. The stipulated general proviso is liberal treatment of the bushes throughout the growing season. When the three years have expired the pruning necessary is a kind of high medium prune as the growth of wood has become so thick.

In the plains, unpruned bushes produce poorer tea throughout the season than annually pruned bushes do. Whether this is true or not in hill gardens has not been definitely proved, but leaving unpruned apparently does not appear to reduce second flush and autumnal flavour to any marked extent, otherwise one could hardly understand its popularity in a district, the teas of which sell mainly for flavour. Pruned tea is liable to suffer severely from blister blight and thrips, and also comes away much later in the season than unpruned tea. These are important factors in favour of unpruned tea.

On high elevation gardens in Ceylon, a similar system of pruning to that practised in Darjeeling is in vogue, and the tendency is, if anything, to increase the pruning interval to 4 or even 5 years. The general opinion seems, however, to be that quality falls off in the 4th and 5th years. Quality off bushes pruned on 4 or 5-year-old wood is however so much poorer, in the pruning year, that on the whole the increase in pruning interval, by reducing the proportion of first year tea, is thought to be advantageous. On low elevation Ceylon gardens, alternate year pruning, similar to that of the Dooars and Surma Valley, is general. In Java also, pruning cycles vary from two to five years, and annual pruning is seldom if ever done on mature tea.

There are certain important considerations in leaving part of the estate unpruned. It is a great saving of labour and expense. The unpruned bushes yield more crop, and in certain plains districts even, unpruned tea undoubtedly pays. The flushes come earlier, and so modify the rush at the busy season. The dense shade

caused by the upper growth suppresses and kills off small unproductive twigs within the bush, so that when pruned the succeeding year, less expense is required for cleaning out in pruning. The shade also kills off moss in a most remarkable way. One objection to leaving unpruned tea is that when such bushes are pruned in the following year, the new growth takes a long time to start away, and since the wood from which the new growth arises is two or three years old, shoots are less likely to come from the eye nearest the pruning cut than on more vigorous one-year-old wood. This not only results in more dead snags on the bush, but if the next pruning is to be two or three years later, there is a risk of the bush becoming infected with disease through the dead snags, which will remain undisturbed for two or three years. In Darjeeling, possibly because of lower temperatures, less die-back occurs than would be expected in hotter climates, more favourable to the growth of fungi, and where the wood on the bush is probably softer, because of more rapid growth.

SKIFF PRUNING

Some planters are of opinion that the unpruned bushes should have just a little cut off the tops of all the shoots, whether the bushes be high or low, weak or strong. This has come to be known as "skiff pruning". It does not appear however that there is any advantage in doing this, unless in cases where the growth upon the bushes is very irregular, with isolated shoots run out considerably above the general level of the bushes. It is difficult to get coolies to use proper discrimination in trimming them; but a good workable plan is to arrange for skiff pruning to a certain height from the ground, say three feet, for instance; each coolie then has a measuring rod, and all the growth above the measure is cut off, the low weak bushes remaining untouched.

Task work can be arranged by measurement of the ground covered; a definite area of ground covered instead of a number of bushes pruned.

RESTING UNPRUNED TEA

It should be clearly understood that the general practice of leaving tea unpruned is recommended only on the understanding that reasonably healthy and vigorous tea is used for the purpose. If weakly tea is left unpruned, and close plucked throughout the season, results are certain to be disastrous. It is a general practice, and a sound one, to pluck unpruned tea up to the end of the second flush, i.e., about mid-July, and then to leave it out of plucking for the rest of the season, having removed from it a large early crop.

TOP PRUNING AFTER LEAVING UNPRUNED

In the Dooars and in the Surma Valley many gardens leave up to one-half of the area of mature tea unpruned every year, and experience shows that in these districts it is not desirable to leave tea unpruned for more than one year.

Thus pruning, on a garden leaving half the area unpruned, is in alternate years, and on 2-year-old wood. Two problems arise in this pruning, firstly, what length of 2-year-old wood shall be left, and how much growth shall be removed from the bush, i.e., what degree of cleaning out shall be done. Many gardens confine the pruning to a plain cutting across leaving ½ to 1 inch of 2-year wood, and make no attempt to remove unproductive, dead, or diseased wood. This is undoubtedly cheap pruning, and can be done for less than ten rupees per acre, even when "slashing" is avoided. A careful test in the Dooars on tea left unpruned in alternate years, shows that this method of pruning has actually, over eight years, given better crops than more careful clean pruning. When however tea is not left unpruned, but pruned annually, clean pruning gives larger crops of better quality leaf than the cheap cutting across.

EFFECT OF LEAVING IN DEAD AND DISEASED WOOD

It would thus seem that, from an economic point of view, on gardens in the districts which produce no stand-

out quality teas, it will pay best to confine pruning to cutting across every other year. There is however a risk that wood rotting diseases may enter and spread unchecked with the final result that the bush dies. Strangely enough, however, many areas of fine tea over 40 years old may be seen which have had only such pruning treatment as outlined above. So long as a bush is kept healthy, by virtue of supplying it with sufficient plant food, and by not weakening it by over plucking, it is able to resist stem and root diseases to a remarkable extent. Though the upper part of the frame may in the course of a few years become a mass of knots, dead snags and twiggy growth this is all removed by medium pruning, which has to be done at intervals of 15 to 20 years in order to reduce the height of the plucking level.

One cannot escape the conviction that over pruning, both in the early stages and later in life, is more to be blamed for producing weakly tea, than under-pruning.

CLEAN PRUNING

In Assam generally and on some gardens in other districts, at least part of the garden is treated to a more careful top prune than a mere cut-across.

CLEANING OUT

Assam gardens generally and certain gardens in other districts in the plains, aim at making tea of high or medium quality, or at least of better quality than the average for the district. These gardens realize that something more than pruning merely to reduce the height of the bush is required in order to make the best of the quality which the tea bush is capable of giving. It has, in the case of good *jat* bushes of light leaf Assam type, been shown definitely that clean pruning, in Assam at all events, gives tippier teas with stronger and better quality liquors, than cutting across without any cleaning out. There are of course degrees of cleaning out.

Let us consider the growth which is made on a bush during the course of a season's plucking. Some of the shoots arising from the previous year's pruning are strong and produce many pluckings. Others, weaker, produce perhaps only 3 or 4 shoots which are plucked during the season. Others, still weaker, are plucked perhaps once only, while others never reach the height of the plucking level at all. Over the surface of a bush which has been plucked flat through the previous season, the strongest shoots are usually most frequent near the middle of the bush. A healthy bush, after cutting back the previous season's growth, may bear a large number of healthy one-year-old twigs, as thick or thicker than a pencil, some of them spaced as close as one or two inches from each other.

Two problems arise in the process of cleaning out a bush after reducing its height; firstly, shall growth which has produced no crop in the previous season be removed, or shall it be left in the hope that it will strengthen and become productive in the following year. Secondly, if two or more strong twigs are growing close together, shall one or more be taken out, and if so what distance between such twigs shall be regarded as best.

REMOVAL OF UNPRODUCTIVE GROWTH

As far as the first problem is concerned, both experience and accurate experiments show that better quality and increased crop result from the removal of unproductive growth such as is commonly termed "*banjhi*" growth, on bushes which are pruned annually. Bushes from which all such *banjhi* growth is removed, not only at the pruning level, but all over the bush, suffer hardly at all from red spider attack, which can be and frequently is very severe in some districts, in April and May particularly, on bushes which are not cleaned out. (*See* Chapter on Pests and Blights.)

In the case of annually pruned tea, then, the question of the removal of unproductive growth of the previous season is one on which no doubt exists at the present

time. The second question, how much productive growth shall be removed, is one which is much debated in Assam, mainly from the point of view of quality. It is argued, firstly, that thin twigs produce poor quality shoots, with thin small buds; secondly, that even if twigs are strong, they do not produce such good quality teas if closely spaced, than if some are removed so that only one or at most two are left at the end of each branch.

STICK PRUNING

This involves drastic removal, not only of weak but also of many strong twigs, and crop suffers very considerably. This extreme of cleaning out is described as stick pruning and is nowadays seldom done.

SPACING OUT

A less drastic form of clean pruning is the spacing out of twigs to a distance of not less than 4 inches, or roughly a hand's-breadth. This also involves, as in stick pruning, removal of some strong twigs, but nothing like as many as in stick pruning, and though crop is lost by spacing out it is not nearly so large as in the case of stick pruning.

Spacing out and removal of banjhi, weak and diseased wood is a very common form of clean pruning in Upper and mid-Assam, and it is claimed that this form of clean pruning gives teas with better tip and quality of liquor. It is very doubtful however whether anything more than a very light clean out, removing nothing but banjhi twigs and diseased or dead wood, would pay on the average garden making good or medium quality teas.

REMOVAL OF BANJHI TWIGS BY HAND

The small banjhi twigs found growing on the surface and inside the bush can easily be removed by hand. This has been found quite a satisfactory method of removing such growth, and the small scar left on the stem heals over readily on a healthy bush.

TRAILING SIDE BRANCHES

Side branches which trail almost to the ground, because they are insufficiently strong to support the weight of leaf and twigs or flowers and seed, should have sufficient growth removed, by heading back or by removal of side twigs, etc., to relieve the branches of some of the weight, when they will commence to grow upwards and in time become part of the plucking surface. As little as possible side growth should, in general, be removed, however, since it is only by leaving the sides that wide spreading bushes which cover the ground can be obtained.

FLOWERING BRANCHES

Many bushes, especially of China and hybrid types tend to produce many flower buds, especially on side branches. These should be removed, on bushes required to produce the maximum crop of leaf, either by heading back the side branches, or by stripping off the flower buds by hand.

LENGTH OF NEW WOOD LEFT IN PRUNING

It is usual to prune to one or two "fingers" of new wood, or ½ to 1½ inches above the previous year's pruning level, in ordinary top pruning. It is better to err on the side of close pruning, rather than long, if only because it puts off the day when the bush becomes too high to pluck, and has to be cut back. If the pruning is to a level, and half an inch above the topmost pruning mark of the previous year, it will be found that ample wood has been left all over the bush, because the new wood which is being pruned seldom arises from the exact level of the previous year's pruning but generally half an inch or more below it. Thus the total length of new wood is about one inch, on which length two new crop-producing shoots are almost invariably thrown out, sometimes more. On side branches, growing out at an angle, the new wood will naturally be longer than on the centre

vertically growing branches, if the bush is pruned flat, as is almost invariably the rule nowadays.

The old style of pruning to form a convex surface was done with the mistaken idea of giving a larger plucking surface to the bush. All that resulted was, however, that the strong centre of the bush was less severely plucked than the weaker sides; and the bush was prevented from spreading and covering the soil. Good plucking on a convex surface is much more difficult than on a flat surface.

PRUNING OF "KICKERS"

Frequently new vigorous growth comes from low down on the bush, especially near the centre, and the question is often asked as to the height at which these "kickers" should be pruned. It has been observed that if pruned down 4 or 6 inches below the general pruning level, a common practice formerly, the new shoot which comes up is thinner and produces less leaf than if the "kicker" is pruned at the general pruning level. It was formerly thought that the lower pruning would cause the "kicker" to branch out but this seldom happens, and it is therefore sounder to prune "kickers" at the general level.

SKIFFING

The extremes of top pruning are skiffing, or removing only the top two or three inches of new growth, and "bagjan" pruning, in which no new wood is left, the cut being made through the previous year's pruning cut. Skiffing as generally done nowadays consists in removing a little of the top growth off the bush so as to obtain a level plucking surface. If plucking has been regular and good in the previous season skiffing is unnecessary but if centres have grown very strongly, plucking is facilitated in the following year by skiffing level.

Tea treated in this way is regarded actually as being unpruned since the skiffing operation does not cut into

red wood, and removes very little growth from the bush.

SKIFFING UNPRUNED TEA IN DROUGHT

The practice of rapidly skiffing unpruned tea which is suffering from drought is one which is to be strongly deprecated. Even when the leaves and young stems are completely dried up, it is better to leave them alone till next year, when a clean job can be made of removing the dead growth efficiently.

BAGJAN PRUNING

The chief object of bagjan pruning was to maintain the bush at a constant height for a number of years and so to put off the day for medium or heavy pruning. The effect of pruning at the same height, through previous year's pruning cuts, is to cause the ends of all branches to become thickened and knotted. In spite of this the method has proved successful on several gardens and gives good crops over 4 or 5 years at any rate. It is doubtful, however, whether quality is as good as in the case of ordinary top pruning, since the shoots plucked off "bagjan" pruned tea must have arisen mostly from two-year-old wood at least, and such shoots are well known to give poorer quality than shoots arising from one-year-old wood.

SEASON FOR TOP PRUNING

The most convenient time of the year for top pruning is from the end of November to the end of March. Experiments, however, show that pruning after the end of December results in loss in crop, which loss increases the later the pruning is done. This loss is of course to a great extent on second flush tea, while little or none of it is made up for later on in the season.

It is therefore general in Assam to try to get the garden pruned in December or before the end of January

at latest. It is not however possible on many gardens to have the whole garden clean pruned by the end of January, and it has therefore become a common practice to cut across the whole garden first, finishing by the end of December or middle of January, and to go round again to clean out. This is a satisfactory procedure provided the cleaning out is not delayed till the new buds have started to shoot. The job of cleaning out then becomes very difficult and beyond the powers of the average garden labourer, if it is to be done without damage to new growth; it is far better in this case to leave well alone.

EARLY PRUNING AND RED SPIDER

Early pruning (December or earlier) has been blamed for encouraging severe red spider attack, and to some extent this is true. If however the bush has been well cleaned out, that is, all *banjhi* growth removed, healthy tea does not suffer severely from red spider. The worst attack always occurs on early pruned tea which is not cleaned out at all.

SLOPE PRUNING ON HILL-SIDES

Some gardens in hill districts, or in districts such as the Surma Valley where much of the tea is put out on teelas, have for many years pruned and plucked such tea on a slope parallel with the slope of the hill-side. Such areas look very well, and the tea pruned and plucked in this way covers the surface of the slope in a very effective manner, thus reducing jungle growth and the drying effect of the sun on the soil. Plucking is also much easier for the women once the surface of the bush has been established, especially when the plucking level is getting fairly high, when with ordinary horizontal pruning and plucking one side of the bush would be almost out of reach while the other side would still be at an easily pluckable height from the ground.

CUTTING BACK

When the bush gets too high to pluck efficiently it becomes necessary to reduce its height. There should be *no other reason than this* for cutting a bush back, if previous pruning has been on sound lines. Moreover, if height has not been wasted by leaving unnecessary growth in top pruning, the intervals between cutting back should be much greater than they have been in the past. Let us consider, first, a bush decentred to a height of say 8 inches on the centre stem, and sides cut to 20 inches after its first year in the ground; unpruned the following year; pruned to 21 inches in the third year; and half an inch of new wood per annum left in in succeeding years. The pruning level will have reached, in the 26th year from planting, a height of 32 inches, and the plucking level say 40 inches. This is still a height at which efficient plucking can be done, but is getting near to the limit. Assuming that the bush is medium pruned at 24 inches at the end of the 26th year, pruned to 25 inches and carefully cleaned out in the following year and then given half an inch per annum subsequently, it should again go for 25 years before needing another cut back.

This assumes ideal conditions in annual top pruning, but allowing for mistakes, there can be no reason why an annually pruned bush should not go for 20 years at least before being cut back. Biennially pruned tea, such as is common in the Dooars and Surma Valley, should of course go for a much longer period without becoming too high for plucking.

ADVANTAGES OF MEDIUM PRUNE OVER HEAVY PRUNE

The reasons for not cutting back below about 24 inches are, firstly, that the lower one prunes the greater the reduction in breadth of frame. Such low pruned bushes take much longer to recover their original breadth than if higher pruned, and therefore take longer to cover the soil. Secondly, the lower the pruning, the larger

will the area of the cuts be, as a general rule. In fact for very heavy pruning and collar pruning the saw is a necessity, so thick is the wood to be cut. Such large cuts seldom or never heal over, and leave open wounds for fungus diseases to enter and spread to the heart of the bush. With the higher cut, wounds are in general smaller and heal over more readily. Even if they do not, and become subsequently diseased, there is still some latitude left for their removal if this becomes necessary.

Thirdly, the heavier the cut, the heavier, and the more prolonged, is the loss not only of crop, but of much more importance, quality. It is generally considered that very heavy pruning or collar pruning causes reduced quality for at least six and possibly for as long as ten years.

The above considerations weigh heavily against any form of heavy pruning. It is typical of heavy or collar pruned areas, that there is not only a considerable percentage of infills or vacancies, but also, a larger percentages of "half-bushes", bushes on which one side has died back completely and has not been replaced by new growth. Such bushes yield perhaps an average of 4 or 5 maunds of tea per acre at best, and are always dying out and having to be replaced. It would not be rash to say that an area of mature tea, 10 years after collar pruning, frequently contains not more than 50 per cent of the original bushes in a healthy state. On similar tea properly medium pruned, observations show that not more than 10 per cent of deaths are likely to occur during a 10-year period after the medium pruning.

PRUNING AFTER CUTTING BACK

One mistake often made, which is responsible for the necessity of more frequent cutting back, is that of leaving too much growth in the two or three years immediately following cutting back. There is nothing to be gained by leaving more than one inch of new wood above the level of the medium prune. It must be remembered

that, after pruning to 24 inches, new growth seldom comes from the 24 inch level (unless the cut happened to be through a knot). The average new shoot arises 2 to 4 inches below the pruning level, so that if the next pruning after a 24 inch cut back is to 25 inches, the average actual length of new growth is at least 3 inches, frequently more.

LEAVING UNPRUNED AFTER CUTTING BACK

It is a common practice in many districts to leave tea unpruned in the year following cut back, the idea being to get thicker wood to prune on. There are objections however to this practice. Firstly, after cutting back there will inevitably be a large number of dead snags due to the new growth not coming away at the pruning level. These should be removed as soon as possible to prevent wood rotting fungus diseases from spreading to the lower parts of the bush. By leaving the bush unpruned, however, such snags remain on the bush for two years following cutting back. Furthermore, after leaving unpruned, the following year's pruning is on two-year-old wood, which neither heals up so well, nor throws out new growth so well, as vigorous one-year-old wood. There is nothing to be gained by pruning on very thick wood.

Perhaps the greatest objection to leaving unpruned after medium pruning is that the bush is made to produce a large crop in its unpruned year, whereas the very fact that it has not produced thick wood in the year after cutting back is an indication that it is not as yet strong enough to be called on to produce the large crop which is often forced from it by plucking it unpruned.

RESTING BEFORE CUTTING BACK

Generous growth after cutting back is required to restore the vigour of the tea, and it is also a wise plan to rest an area from plucking before it is to be cut back, especially if the area in question is below average in vigour and cropping capacity. Many gardens rest areas

which are to be cut back, for the whole season previous to cutting back. Others throw such areas out of plucking at about the end of July, having taken off the valuable second flush crop.

RESTING AFTER CUTTING BACK

Again it is sometimes the rule to leave cut back areas unplucked for a year after cutting back. In other cases the bushes are left untouched till they reach a height of about 4 or 5 feet and are then cut across at 3½ or 4 feet in August or September, the object being to check centre growth so as to encourage side growth. Normally healthy tea may be safely plucked throughout the season following cutting back, and provided not less than 10 inches of new growth is left in tipping, such regular plucking is probably the best way of ensuring an even thickness of wood on the new growth all over the bush.

TIME FOR CUTTING BACK

As in the case of the pruning of young tea, the time at which medium pruning is done is of very considerable importance. The operation, depriving the bush as it does of all or nearly all of its leaf, must be done at a time when there are ample food reserves stored up in the frame and roots. Otherwise the bush is left with little or no reserve food, and at the same time no means of manufacturing such reserves (the leaf being the factory in which such reserves are made). A bush medium or heavy pruned, for example in August or September having previously been regularly plucked, is not likely to have much in the way of reserves. After pruning, new growth, favoured by climatic conditions obtaining at the time, comes away well, and the results of the pruning appear to be quite satisfactory. In producing this growth, however, all available reserves are used up and there is likely to be a period when the bush is practically without reserve, before the new growth is in a condition to produce fresh supplies. During this period the bush

is in a vulnerable condition in regard to fungus diseases such as red rust, branch canker, etc., and it has been observed that time of medium or heavy pruning has a marked effect on subsequent liability of a bush to stem disease. Bushes pruned during the period of vigorous growth when reserves are low, i.e., April to October, were subsequently much more attacked by stem disease than those pruned in the period when there is little or no growth, i.e., November to March, and when reserves are at a maximum.

It is not fair to compare the effect of rains and cold weather cutting back in, say, the following spring. Naturally the bushes pruned earlier (that is in the previous rains) have made more growth than the later (cold weather) pruned bushes. Comparisons should be made after 2 or 3 years, when the effect of stem disease will have had time to show up. It will then be apparent that much more dead and diseased wood needs to be removed from the frames of the bushes which were cut back at the time when they were low in food reserves.

Of course if tea is left unplucked for a season before cutting back there is likely to be more reserve in the bush towards the end of that rains, and such bushes will be better fitted for cutting back in September, than similar bushes which have been continuously plucked up to the time of cutting back. Nevertheless even if unplucked prior to cutting back, better results are to be expected by delaying the pruning till the cold weather.

LEAVING "BREATHERS" IN CUTTING BACK

It is the general practice in Ceylon when cutting back a bush, to leave a number of branches, usually three to six on the perimeter of the bush unpruned, to act as "breathers" during the period when the bush is otherwise denuded of leaf. This is known in Ceylon as "rim-lung" pruning and is really exactly the same as the "leaving of kickers" which has been employed in North-East India for many years, though only on a few gardens.

After the pruned branches have produced good new growth the kickers are cut away. This practice of leaving "kickers", or "lungs", is sound theoretically and has given good results in the low country in Ceylon, though not at medium or high elevations.

TREATMENT OF PRUNING CUTS

The necessarily large cuts made in medium or heavy pruning do not generally callus over readily and become almost invariably infected with one or other of the wood rotting fungus diseases. On vigorous tea, such disease may be confined mainly to the dead wood, but if the tea is at all debilitated, the disease is likely to extend and ultimately to cause the death of the bush. For many years various methods for encouraging callus formation and for preventing disease infection through pruning cuts have been tried. So far, however, no single treatment has been found which will prevent infection and at the same time encourage callus growth. Any fungicidal wound paint which does effectively prevent infection also tends to interfere with callus formation. The best treatment which can at present be advised is to treat the cuts immediately after pruning, with lime sulphur solution of a strength of 8° Beaume or thereabouts, and then to treat the cuts with bitumen paint after the lime sulphur solution has dried. A convenient bitumen preparation consists of 6 parts by weight of bitumen melted and mixed with 4 parts of kerosene. This forms a semi-fluid mixture which can be applied with a stiff brush and is able to fill up the cracks which form between the wood and the bark round the edge of the pruning cuts.

INFLUENCE OF PLUCKING ON CALLUS FORMATION

The amount of leaf allowed to remain on the bush during the season following medium or heavy pruning has a considerable effect on callus formation. It is not however necessary, or advisable, to leave such tea entirely unplucked. For one thing, growth under such

conditions will tend to be strongest in the centre of the bush and side growth comparatively weak. On the other hand, by plucking cut back tea to a measure, centre growth is checked and side growth is thereby encouraged. A satisfactory height for tipping 20 inch cut back tea is about 32 inches, i.e., a foot of new growth. Subsequently the bushes can be plucked without breaking back. This system of plucking results in satisfactory callus formation, and an even thickness of new wood over the surface of the bush.

SUN-SCORCH AFTER MEDIUM PRUNING

The sudden removal of the "top hamper" of a big and wide-spreading bush leaves the lower frame exposed, with the result that the branches, especially on their South-facing sides, become sun-scorched. The effect is not easily noticeable for some months after the operation of medium pruning, and is frequently attributed to disease.

Sun-scorch can be avoided by sowing boga medeloa in alternate lines running East and West, in the spring, for tea which is to be cut back in the following cold weather. It is generally necessary to lop the side branches of the tea bushes in the rows where the medeloa is to be planted, so as to allow the medeloa to grow. By November the medeloa will be at least 4 or 5 feet high and will provide the necessary shade to protect the tea after cutting back.

CHAPTER IV

REPLANTING AND RENOVATION

ALTHOUGH practically no planting out of tea on virgin soil is done nowadays, a brief description of methods employed some years ago is of interest.

Opinion was somewhat divided as to the extent of preparation necessary in order to ensure success. The wisdom of very elaborate preparation was in the early days sometimes questioned, but later, as a result of experience, the tendency became distinctly in the direction of more thorough work, as being the best economy in the end.

ROUGH METHODS

In the early days of planting tea, it was very customary merely to cut grass land, burn it, grub out the roots of elephant grass, stake and dig holes, and then put seed at stake—sometimes germinated and sometimes not. The large roots of elephant grass were set on edge to form a partial shade for the young plants when they appeared.

It was wonderful how successful the planting of some gardens was, although the method was so rough. This was no doubt due in a large measure to the advent of good spring rains, and to the initial high level of fertility in the soil, although also of course to careful and efficient supervision. On the other hand, many clearances treated in this rough way proved an utter failure. The general result of experience ended in more caution being exercised, and more thorough preparation the rule.

FOREST CLEARING

For clearing forest land, the system generally adopted was to commence operations immediately at the close

of the rains, cut brush-wood and undergrowth, then leave it to dry, after which a fire was sent through it. The trees were then felled, leaving as short a stump as possible: the branches were lopped and time again given for drying, when fire was sent through again. All heavy timber remaining after the second fire was then prepared for enginewood or charcoal and removed to the factory. The land then received a good hoeing all over, all small roots being extracted, and only the roots of large trees left to rot away in process of time.

STUMP ROT

In some parts of Assam the following was a common experience after clearance of forest land. After the stumps of trees had begun to rot and the young tea plants were three or four years old, the tea on large patches of ground here and there gradually died out, leaving a vacant space about 20 feet or more in diameter. The damage was done by fungus diseases which originated from the rotting stumps of trees. Some trees were considered more liable to disease than others, and certain climatic and soil conditions to favour its spread more readily than others; but after becoming established upon a rotting stump, it gradually caused the death of all tea-bushes in the vicinity and became widespread if left unchecked.

The only precaution regarded as satisfactory was to grub up all the tree roots at the time of preparation of the land.

THOROUGH CLEARING

This leads us to the consideration of the system of more thorough clearing and preparation previous to planting new land. It was much more expensive than the usual plan, but yielded very satisfactory results.

Instead of trees being cut down they are uprooted. A large ring is dug round and the lateral roots cut, when the weight of the trunk and branches helps to complete

the work and, in falling, tears up the remainder of the roots.

BAMBOO CLEARING

Bamboo clumps are treated in the same way, although in this case the work is exceedingly laborious and expensive, sometimes as many as twenty-five or thirty coolies being required to uproot one clump. After the clump has been turned on to its side, the bamboos are all cut off short at the root, and if the clump is a large one, it must be divided into several pieces before it can be removed. On steep hill-sides, the removal of these roots and stumps is simple, as they are just rolled downhill into the ravines, but on the plains there is great difficulty, all roots having to be dragged away.

On some gardens in Assam, as well as Darjeeling, this system of clearing has been carried out with great success and very satisfactory results.

TREES IN TEA

It was generally considered desirable to have a few trees standing in the clearance in order to give shade here and there to pluckers. Some kinds of trees were considered very injurious to tea and it was regarded as dangerous to the surrounding tea to allow them to remain. Amongst these were the sal, the various kinds of chest-nut, the chillownee, etc. It was however early realized that there are certain kinds of trees, the leguminous types for example, which far from doing harm, are beneficial to tea growing under them.

In general, leguminous types of trees are now known to be very beneficial and in fact almost indis-pensable to production and maintenance of high yielding healthy tea.

TRENCH-DIGGING

After the roots had been all grubbed and cleared away, the land generally received a trench-digging all over. The coolies started at the boundary line and dug

at least 18 inches deep, pulling the soil back and so forming a trench; as they worked forward, they filled this trench in and also formed a new one, keeping a trench always ahead of them. In this way it could be seen that the ground was dug thoroughly to the required depth and the soil well mixed. All lumps were broken up, all stones and roots sorted out and thrown up on the surface to be collected and carried off by gangs of men and children coming behind.

In modern practice tractor ploughs are very often used to prepare land for replanting. Very deep ploughing is unnecessary; the equivalent of a 9″ deep hoe is all that is required.

WALLS TO PREVENT WASH

On steep hill-sides a sound practice was to use the stones thus brought to the surface for building along the sides of roads, and for building low walls or terraces at intervals across the hill to prevent loss of soil by wash during the rains. By this means the stones which are usually considered a nuisance become of great value to the property, as a means of retaining the best constituents of the soil by preventing wash during the many years of cultivation to come.

REPLANTING

Under the present Restriction Act no tea may be put out on virgin soil without permission, obtainable only in very special circumstances. Replanting may of course be done, but only on land which was bearing tea in plucking on the 31st March, 1931.

For this reason problems connected with planting on virgin soil are dealt with in less detail than those attendant upon replanting of old tea areas.

The need for replanting arises when an area of tea has become unproductive for one of the following reasons:—

(*a*) Extreme age of the tea.

(*b*) Death or debility, through disease, impoverishment of soil or bad cultural methods, of a large percentage of the bushes.

It is also often considered desirable to uproot and replant areas of tea of undesirable jat, e.g., China hybrid, and to replace it with good jat tea.

It is well worth while making a good job of replanting, with a view both to the subsequent quality as well as to the outturn of the replanted area. A policy of skimping, resulting in the saving possibly of a few rupees per acre, may and often does result in the annual loss of several hundred times the original saving.

UPROOTING OF TEA BUSHES AND SHADE TREES

The first essential to the preparation of an old area of tea for re-planting is the complete removal of the old bushes and trees. Many people consider it a waste of time and labour and an unnecessary expense to remove what appear to be young and healthy shade trees; it is however more generally the opinion that a "clean sweep" is much the best. The average healthy life of a shade tree such as the sau, or siris (*A. stipulata*), is at the most 20 years, while often it becomes cankered and decayed long before this, and is then a source of trouble. If left in it is liable to infect surrounding tea and shade trees with root-rot and other fungus diseases. Its removal from amongst surrounding tea bushes is an expense and liable to result in damage to the bushes. If, however, when the old tea is uprooted, the shade is also removed completely, new shade can be established universally over the area, and when the time comes to remove it, this operation can be made to coincide with the cutting back of the area. The felling of the trees is then unlikely to do damage which cannot be repaired during the pruning of the tea.

Care is necessary to ensure that as far as possible all roots and pieces of tea bushes and trees are removed from the soil and taken right away or burnt. It is bad practice to pile wood into large heaps and burn them

Fig. 6.—Illustrating Method of Triangular Planting.

on the land to be replanted. The wood ash contains much potash and soda which may not only cause the soil to become too low in acidity to grow tea well, but, in the case of soda at any rate, is very liable to ruin the tilth of the soil. If wood is to be burnt the ashes should be scattered well over a large area. Areas to be replanted, having perhaps carried poor tea for many years previous, are often thatch-ridden or at least carry considerably more of the undesirable forms of weed than is usual, or good, for tea. Hence a good deep hoe is required. The thatch and other deep-rooting jungle should be either removed and burnt or else well buried when the soil is dry. This deep hoe also serves if properly done to level off the soil, and to flatten out white-ant "teelas". These consist of soil which is low in acidity, often alkaline, and will not grow young tea. The best method of dealing with them is to dig them out and to spread the soil thinly over the surrounding land. Sulphur in the form of flowers of sulphur or ground sulphur is then broadcast and hoed in wherever white-ant soil has been spread. The sulphur can be applied at the rate of 5 mds. per acre or roughly 1¼ lb. per square null. The application should be doubled over the area actually occupied by the teela itself.

DRAINAGE

Many areas have become poor and unproductive owing to inefficient or inadequate drainage, and before new tea can be established it is obvious that the drainage system must be overhauled. This may involve filling up of existing drains, and making new ones. On sloping land contour drains and bunds will be necessary; e.g., on low land surrounded by hills, or teelas, some system of contour draining is required to prevent wash and seepage from the surrounding higher land to the flat.

LIGHT SOILS

Light friable soils grow tea very well, but only if there is a sufficient rainfall, well distributed. In a

climate which is subject to long droughts of, say, five to seven months with practically no rain, the stiffer more loamy soils stand the strain best provided they are kept in good tilth.

CLIMATE AND RAINFALL

The rainfall necessary for tea is upwards of 200 inches annually, and the average for the existing tea districts is probably between 70 and 150 inches.

The best conditions exist when this rain is distributed over the whole year, with the heaviest showers during the hottest weather.

FROST AND SNOW

Moderate frost and snow have no ill effects upon tea, which although overgreen, is practically dormant in North-East India during the winter season. Frost has a beneficial effect in killing off the eggs or grubs of insect pests, and it has been noted that gardens at high altitudes are comparatively free from such attacks. On the other hand, tea at high altitudes is more liable to get loaded with mosses, fungi, and lichen of all sorts, especially if badly treated.

EFFECT OF CLIMATE

In the lower lying portions of Assam, Cachar, Dooars, etc., where the climate is humid and forcing, great quantities of tea are produced per acre, and, with favourable conditions, the tea produced may be very strong, but it has hitherto been found impossible to get fine flavour in those districts, unless very occasionally, when autumn has modified climatic influences or in the second flush period of May and June when green fly blight has aided the tea maker.

JAT OF TEA

While climate, and possibly to some extent, soil may play a part in governing flavour and quality, the

jat of tea is a very important factor. Certain well-known Assam light leaf jats may generally be relied on to give a higher standard of quality than the dark leaf jats, but even so there is very considerable variation amongst the light leaf jats themselves. This matter is discussed more fully in another chapter. In Darjeeling the finest flavour is considered to come from bushes of China and China hybrid jats.

Fine flavoured teas are produced in the milder climate of the Darjeeling Hills and of Upper Assam; and yet it must not be taken for granted that all the land within those districts will produce finely flavoured tea.

QUALITY DISTRICTS

There are localities within each of the quality districts, where whole groups of gardens almost invariably turn out fine teas at certain seasons; and other localities, apparently similar, where fine teas are seldom or never produced.

NURSERIES

Having selected the area for replanting, the first operations are to be directed towards the preparation of nurseries. These should be made in various places where suitable plots can be found. There is no ban on planting of nurseries on virgin soil, provided certain rules are observed, and it is best to make use of virgin land for nurseries, if it is within reasonable distance of the area to be replanted. If not, then it will be necessary to make use of areas either adjoining or within the area to be opened up: the former for preference, because a tea nursery has an impoverishing effect upon the ground, partly owing to the large amount of nourishment taken up by the young plants growing closely together, but chiefly from the quantity of the surface soil which is carried away with the seedlings in transplanting.

The plots selected for nurseries should be at frequent intervals and convenient distances, so that when the time

comes for transplanting, the seedlings will not require to be carried far. They should also, if possible, be in comparatively shady places with water convenient.

As the subsequent transplanting is done nowadays almost exclusively by means of "ball planting", i.e., plants are lifted with a cylinder of soil round the roots, and in the dry season, it is imperative that the soil of the nurseries should be as free as possible of stones or gravel, and that it should not be too sandy.

If it is necessary to put out nurseries on very sandy soil, the soil should be allowed to compact before putting out the seed, and should be disturbed as little as possible while the plants are growing. In the chapter on tea seed and tea nurseries, the preparation and maintenance of nurseries is dealt with in more detail.

GREEN CROPS

After old tea has been uprooted and the land hoed up it is customary, and a very good plan, to leave it under green crop such as boga medeloa (*Tephrosia candida*) or Arhar dal (*Cajanus indicus*) for a year before replanting. Both crops grow best if sown in lines about 4 feet apart, and their shade prevents to a great extent jungle growth during the rains, while the soil is enriched by the leaf droppings and the green stuff which is hoed in at the end of the season, before replanting.

DISTANCE APART, AGE AND TIME FOR PLANTING TEA

A suitable distance apart for planting, and one most commonly employed on flat land nowadays, is $4\frac{1}{2} \times 4\frac{1}{2}$ feet for triangular planting, or 4 feet 3 inches for square planting. In most districts the time of the year for planting is November, December and January up to such a time as the soil becomes too dry for the young plants. Early rains planting is sometimes done, but its success is considered doubtful by many experienced planters. The most suitable age of the plant at the time of planting is also a subject of controversy. Some

people, probably the majority, prefer one-year-old plants, while others prefer two-year old. Others again, who plant in the rains, prefer six-month-old plants. Probably a great deal depends on climate, jat and other conditions but, as a general rule, success seems most to attend the planting of one-year-old plants in November or December, providing a reasonable good nursery is used.

PLANTING UP

In planting out the young plants the best results are obtained by taking as large a ball of earth round the roots as possible. This "bheti" or "dela" should extend from the collar to the bottom of the tap root. If it breaks some of the roots are inevitably torn or damaged and in planting the exposed tap root is bent. When this happens, even if the plant lives, it is generally much less vigorous than one undamaged in transplanting.

CARROT PLANTING

The method of "carrot planting", that is, planting with no soil at all round the roots, is not now common in North-East India, but is still the rule in Ceylon where plants are often transported for long distances in bundles. This method of planting apparently proves satisfactory enough, when the plants are put out on good soils, and are watered and otherwise carefully tended after planting, but it is never so successful as "ball" planting. The latter method is always to be preferred, where practical.

The holes for planting should be about 2 feet wide and the depth of the plant from collar to root tip. In stiff soils, or soils with stiff subsoil, the earth at the bottom of the hole should be loosened up to break any "pan" which may have formed and then gently tamped down. The soil which is returned to the hole after planting should be mixed with about 10 lb. of good-well-rotted cattle manure or compost and should be pressed firmly in as the hole is being filled up. Young plants benefit from the bulk organic manure not so much from the nitrogen

supplied as from the effect which the manure has on tilth and moisture holding capacity of the soil. Such bulk organic manures also contain vitamins and plant hormones, substances which stimulate root growth. Young tea plants may benefit considerably from this stimulus.

GREEN CROPS IN YOUNG TEA

It is now very general to sow boga medoloa in every row, or in alternate rows, in replanted tea and this, provided certain rules are observed, is a very sound practice. The best time for sowing medeloa is after the first spring rain in late February or March. A good crop will have grown sufficiently to be lopped up the sides by July or August and should be again lopped in October before the start of the cold weather. In the second year if the medeloa has been sown in every row in the first year, alternate rows should be uprooted. Three loppings, viz., in May, July-August and October, may in addition be made, and the plants finally uprooted in May of the third year. It is very important to lop the sides of the plants prior to the cold weather, especially in droughty districts as, although the boga medeloa prevents evaporation of moisture from the soil by its shade, it removes far more moisture by transpiration through its leaves. By lopping the sides severely this loss of moisture by transpiration is reduced greatly, without seriously reducing the effective high shade.

It is better not to hoe in the lopping, but to leave them to lie and rot on the surface of the soil. By doing this they help to keep down weeds, and also provide a surface mulch which protects the soil from drought.

SHADE TREES

In replanted areas shade trees are normally planted up at that distance apart which is considered satisfactory when the trees become mature, i.e., 40 to 50 feet apart. Unfortunately, as even the quick growing types of shade trees take 6-8 years to produce an effective canopy, (and therefore an appreciable quantity of leaf fall), they are,

unless planted much closer together, of little use to the young tea in these earlier years. For the first 2 years this is not of much consequence, as the tea gets all it needs in the matter of shade and manurial value from boga medeloa. It is after the medeloa has been removed and before the shade tree has matured, that the tea is liable to suffer, i.e., in the 3rd to 6th or 8th year, and it is frequently found that red rust is most prevalent during this period. One is often deterred from planting the slower growing types of shade in replanted areas as these trees take so long to reach a reasonable size that they are useless to young tea for upwards of 10 years.

It is suggested that any rate a partial solution to the problem may be found by a system of much closer initial planting of mixed slow and rapid growing shade, with the object of thinning out the rapid growers when their canopy is fairly large *but before they become too big*.

There are several methods of planting shade trees all of which find favour in one district or another. In some districts "seed at stake" is a common method. Other more general methods are stump planting and planting out from a nursery, exactly as with tea. The last method has generally been found to be the best. In the chapter on shade trees, methods of planting are discussed in more detail.

CULTIVATION OF YOUNG TEA

Although it is well known nowadays that tea does not benefit from soil-stirring, it is nevertheless necessary to keep down weed growth and for this reason alone weeding, hoeing, cheeling or some efficient means of suppressing jungle growth is essential. This is especially true of young tea which is unable to suppress jungle growth to any extent by its own shade. Extensions or replanted areas suffer greatly by being allowed to "go under jungle". Since much damage may be done to the roots of the plant by hoeing and forking it is important to see that the hoeing men do not hoe within

1 foot of the plants. A circle of 1 foot radius round each plant should be kept clean by hand weeding, assisted where necessary by the use of a hand fork, the sole function of which is to loosen the deeper rooting weeds, so that they may be easily removed by hand. A great mistake often made in replanting is to tackle too large an area to keep efficiently cultivated during the following two or three rains.

DRAINAGE AND BUNDING

A careful inspection of a replanted area during the first rains will show whether the drainage and bunding has been efficiently done. It is better to start with too few rather than too many drains, and to put in more if subsequent observation shows that they are necessary. Often much can be done by hoeing up contour bunds on slopes liable to wash. These bunds need only be ridges about 6 inches high and 9 inches wide at the base, but should have attention annually, at the same time as the cleaning and repairing of drains is done.

COVER CROPS

One very valuable aid to the prevention of soil wash and to the preservation of soil tilth which has had little attention paid to it in North-East India is the use of cover crops. An ideal type of cover crop would be a legume of creeping habit. The object of such a crop is threefold; firstly, its presence in and on the surface of the soil prevents loss of soil by surface erosion, and loss of tilth by protecting the surface from the beating of the rain; secondly it is expected to enrich the soil in organic matter and nitrogen; while thirdly its presence should hinder the growth of undesirable weeds.

Clovers, *indigofera endecaphylla*, *desmodium* species and possibly certain common indigenous weeds are among the plants which might be tried out as cover crops for young tea.

CHAPTER V

A GENERAL OUTLINE OF THE MAIN TEA SOIL GROUPS OF NORTH-EAST INDIA

GEOGRAPHICAL DIVISIONS

THE tea bearing areas of North-East India may be grouped geographically into three main divisions. That which occupies the whole of the North-East Assam is considerably the largest and the tea gardens have been put out on an alluvial plain drained by the Brahmaputra river and its tributaries, and bounded on the north by the Himalayan foothills and on the south by the Naga, Mikir and Khasia Hills. Though there are gardens on both banks of the river, the majority are on the south.

A second tea area in the Province of Assam is that drained by the Barak and Surma rivers which flow into the Megna river. This river joins the Ganges almost at the apex of its delta. This tea area, comprising the districts of Cachar and Sylhet and known generally as the Surma Valley, is also an alluvial plain, and is surrounded by the hills on north, east and south. Tea gardens have been put out on the plain itself and also on the lower slopes of the foothills.

The third large tea area is in Northern Bengal. The tea is put out on a strip of land extending about 20 miles from the foothills, and stretching from the Nepal frontier to the western boundary of Assam. It comprises three districts; the Bengal Dooars, being the area east of the Teesta river as far as the Sankos river (the boundary of Bengal and Assam); the Darjeeling Terai between the Teesta river and Nepal; and the Darjeeling district, being that area of tea put out at more or less high elevation on the hill slopes north of the Terai.

There are also comparatively small areas of tea in the Chittagong, Ranchi, Dehra Dun and Kangra Valley districts.

All of the tea soils of North-East India have been, or are being, developed under optimum rainfall and high temperature conditions. Under such conditions lateritic soils are formed. These are distinguished by being reddish in colour, and contain a very high proportion of sesquioxides of iron and aluminium oxide, in proportion to their silica content. This is due to the solvent action of the carbonic acid, formed by the decomposition of soil humus, on alkaline and sesquioxide silicates in the clay portion of the soil. The soluble silica is leached downwards into the lower horizons of the soil, leaving the iron oxide and alumina behind. The characteristic red colour of such soils is due to their high iron oxide content.

Most of the tea soils are alluvial and of very recent origin so that there has been little time for laterization to proceed far. The great majority of the soils do not merit the term lateritic, and in fact many tea soils can hardly be termed "soils", being merely collections of broken up rock particles; on the chemical composition of which climatic factors such as rainfall and temperature have as yet had no appreciable effect.

MODE OF FORMATION

In some of the older deposits laterization has proceeded to some extent and has produced the Red Bank soils of the Dooars, the so-called "old alluvium" of Assam and the chocolate Darjeeling loam.

Detailed accounts of the formation, together with descriptions of the physical and chemical characteristics, of the main groups of tea soils, are to be found in the various published accounts of soil surveys of the tea districts issued in the Quarterly Journals of the Indian Tea Association.

ASSAM SOILS

In Assam tea has been put out mainly on alluvial soil which varies considerably in physical characteristics but in general is fairly light. Table I on page 86 gives typical Assam soils. No. 1 soil is a typical Upper Assam

light loam and it is on such soils as this that about 100,000 acres of the finest tea in North-East India, and probably in the world, are put out. These soils are of comparatively recent deposition and have been brought down from the sandstones of the Patkai Hills by tributaries of the Brahmaputra. They are lower in silica than the soils deposited probably at a later period by the Brahmaputra from the crystalline rocks of the Tibetan Plateau, which are found in middle and lower Assam. Examples of this later deposit are given as soils No. 2 and No. 3. Soil No. 4 is an older red soil, outcrops of which are found in Lower Assam, and in the Bengal Dooars, where it is called the Red Bank series. These are older, more laterized and heavier soils, and have, as would be expected, a lower ratio of silica to iron and aluminium in the clay fraction, than the new alluvial soils. They also in general contain more phosphoric acid, potash, nitrogen and organic matter than the newer soils, and though generally higher in lime and magnesia, are considerably more acid, on account of their high percentage of clay and organic matter.

DOOARS, TERAI AND DARJEELING SOILS

Table II gives examples of Dooars, Terai and Darjeeling soils. No. 1 is of the Red Bank series, and similar to the Assam old alluvium which has been weathered. Laterization has proceeded to a considerable extent in the case of the Dooars Red Bank series, as can be seen from the low ratio of silica to iron and alumina and from the mechanical analysis which indicates a considerable breaking down of the silt particles to clay fraction. These soils are among the richest in tea.

No. 2 belongs to the Mal Sand series, which occur mainly in the Terai, Western Dooars and low parts of Darjeeling. These soils are black, contain often much mica, and appear to have been old alluvial deposits which have collected considerable store of organic matter during a long period of waterlogging; during which period the process of normal laterization has been unable

to proceed to any appreciable extent. There are however cases, in South Terai for example, where the soils occurs on a raised and well-drained bank. In these cases, as a result of efficient aeration, laterization has gone on and the soil has assumed a chocolate or even a reddish colour. Such soils have a lower ratio of silica to sesquioxide than the normal Mal Sand, and are much poorer in nitrogen and organic matter.

Soil No. 3 is typical of the grey sandy loam of the Eastern Dooars. This series represents an extremely new type of soil, which has undergone very little weathering. These soils are generally high in lime, magnesia and phosphoric acid, and low in nitrogen and organic matter.

A fourth type of Dooars soil is represented by No. 4 in Table II, known as the Hantupara Plateau series, an older soil with some signs of weathering, probably a stage in the formation of the Red Bank type.

The Darjeeling soils include the Mal Sand type found at the lower elevations in the valleys of the foothills, and soils resembling the grey sandy loams of the Dooars which also occur in the valleys; but the typical soil of the hills (No. 5 in Table II) is a loam formed *in situ*, varying in colour from dark chocolate to red. Soils of the latter colour are very similar to the Red Bank type.

SURMA VALLEY SOILS

The soils of the Surma Valley fall into four main groups of which typical examples are given in Table III. The tea in this district has been put out on the slopes of low hills or *teelas*, and on the flats bordering them. The *teela* soils are generally red and sandy and have been weathered to a considerable extent. On this account the clay fraction is often higher than the fine silt. The flats consist of soils washed from the hills and vary in texture from sandy, at the foot of the hills, to stiff clay further away. Plateau soils are generally heavier than *teela* soils and appear to have been washed

TABLE I

Brahmaputra Valley

	No. 1 Upper Assam loam, per cent.	No. 2. Mid-Assam sandy soil, per cent.	No. 3. Lower Assam sand, per cent.	No. 4. Tezpur red soil, per cent.
Coarse sand	23	1	52	23
Fine sand	26	57	25	24
Silt	22	21	13	13
Fine silt	8	13	4	16
Clay	15	4	3	18
Loss on ignition	5·8	3·1	3·0	5·2
Organic matter (Grandeau) ...	1·55	1·35	1·20	2·2
Nitrogen	0·106	0·085	0·071	0·096
Total phosphoric acid	0·075	0·051	0·060	0·046
Available phosphoric acid ...	0·011	0·009	0·012	0·003
,, potash	0·009	0·008	0·004	0·007
,, lime	0·020	0·013	0·033	0·030
Acidity (Hopkins)	490	450	320	720
pH of soil water extract ...	5·7	5·6	5·6	5·2
pH of n. KNO_3 extract ...	4·6	4·5	4·6	4·4
Insoluble siliceous matter ...	84	92	90	80

TABLE II

Bengal Dooars, Terai, and Darjeeling

	No. 1. Red Bank, per cent.	No. 2. Mal Sand, per cent.	No. 3. Grey sandy loam, per cent.	No. 4. Hantupara Plateau, per cent.	No. 5. Darjeeling high elevation, per cent.
Coarse sand	10	55	8	25	13
Fine sand	9	19	28	30	10
Silt	20	8	29	13	15
Fine silt	20	10	26	17	23
Clay	32	4	7	11	30
Loss on ignition	9·8	4·0	3·5	4·3	9·0
Organic matter (Grandeau) ...	3·1	2·4	1·5	2·0	3·5
Nitrogen	0·135	0·130	0·085	0·010	0·180
Total phosphoric acid	0·013	0·090	0·160	0·012	0·095
Available phosphoric acid ...	0·012	0·021	0·055	0·044	0·020
,, potash	0·018	0·008	0·015	0·015	0·043
,, lime	0·025	0·021	0·150	0·035	0·050
Acidity (Hopkins)	1,2000	400	200	500	850
pH of soil water extract ...	5·4	5·3	5·8	5·6	5·2
pH of n. KNO_3 extract ...	4·2	4·5	4·8	4·6	4·6
Insoluble siliceous matter ...	68	86	85	85	71

TABLE III

Surma Valley

	No. 1. Teela, per cent.	No. 2. Clay Flat, per cent.	No. 3. Koomber Plateau, per cent.	No. 4. Peat Bheel, per cent.
Coarse sand	23	*Nil*	13	5
Fine sand	38	9	30	5
Silt	14	15	27	9
Fine silt	8	35	8	22
Clay	10	28	16	10
Loss on ignition	5·5	11·0	5·1	46·0
Organic matter (Grandeau) ...	2·2	4·0	1 6	25·0
Nitrogen	0·12	0·22	0·13	0·60
Total phosphoric acid	0·30	0·072	0·100	0·200
Available phosphoric acid ...	0·14	0·005	0·025	0·050
,, potash	0·12	0·015	0·005	0·040
,, lime	0·05	0·08	0·0200	0·030
Acidity (Hopkins)	800	1,600	1,000	3,000
pH of soil water extract ...	5·6	5·2	...	4·8
pH of n. KNO_3 extract ...	4·6	4·5	...	4·0
Insoluble siliceous matter ...	92	78	84	53

from the hill slopes and subsequently either raised up, or left in position when surrounding higher land had subsided. The Koomber type of plateau soil is a curious one, distinguished by the shortage of fine silt.

Where flats have become waterlogged or flooded, bogs have been formed, and the result has been the formation of rich peat soil known locally as a *bheel*. Such areas when drained are wonderfully fertile and it is on one of these areas that world's record yield of 3,120 lb. of tea per acre per annum has been obtained.

CHAPTER VI

MANURING

DURING the past 30 years or so the problem of the manuring of tea has received serious attention and as a result much information has been accumulated. Its importance is now recognized on all hands, and manuring programmes are the order of the day on all well run estates. It is a subject which deserves earnest and scientific study, because so much money can be saved or wasted, as the case may be.

The Scientific Department of the Indian Tea Association has produced several pamphlets and articles on this subject, the latest of which, "The Nitrogen Supply to Tea" by Mr. H. R. Cooper, in particular is deserving of study by those who wish to get the best results from the money they spend on manuring. There is still much room for study and experiment, particularly in regard to the different response to manuring shown by different soil types; and in regard to the effect of manuring on quality, more especially in districts such as Darjeeling and Upper Assam noted for the high quality and flavour of their product.

Owing to shortage of inorganic nitrogenous fertilizers, the industry had to take in 1947 a mixture containing a total of 10% nitrogen, of which half is inorganic and half organic form, at a cost of Rs. 240/- per ton F.O.R. Calcutta. This mixture replaces that supplied in 1945 and previous war years containing 12½% nitrogen, of which about 7% was inorganic form.

The inorganic nitrogen in both mixtures is in the form mainly of oilcake, together with a certain proportion as waste animal residues such as bone meal, animal meal, hides, sinews etc. The efficiency of the nitrogen in such forms may be as high as 60% of that of inorganic nitrogen, certainly not more. In other words, of the 5% organic nitrogen about 3% can be regarded as

available, giving, with the 5% inorganic nitrogen (100% available), a total of 8% available nitrogen.

No importance or value can be attached to the very small quantities of Phosphoric acid or Potash in so far as their manurial effects on tea is concerned.

Thus, to ensure an application of available nitrogen at the rate of 80 lbs. per acre, 1,000 lbs. of the 10% mixture must be applied, costing about Rs. 107/- per acre exclusive of freight.

An application of 80 lbs. available nitrogen per acre is essential on unshaded tea to maintain a steady crop of 16 mds. per acre without deterioration, and on well shaded tea, to maintain a crop of 20 mds. per acre, with the average soil and climatic conditions in North East India.

If it is possible to obtain the ingredients of the mixture separately, much better value can be obtained. The mixture contains

(1) Inorganic fertilisers—Sulphate of ammonia, and/or Nitrate of ammonia, and Ammonium phosphate.

(2) Bone meal and other animal residues.

(3) Oilcake.

Inorganics containing only nitrogen are best applied on mature shaded tea. Oilcake may be used alone on unshaded mature tea and young tea.

Bone meal and ammonium phosphate both supply phosphate, which is often so necessary for leguminous plants such as green crops in tea, young shade trees, and food crops such as beans, peas and other pulses. These phosphatic fertilisers should be mixed before application with wood ash so that both potash and phosphate are applied to the leguminous plant.

Bone meal and ammonium phosphate both contain about 20% phosphoric acid, and wood ash about 10% potash (K) so that a 2 : 1 mixture of wood ash and either ammonium phosphate or bone meal will contain equal parts of P & K, and a 300 lbs. per acre application gives 20 lbs. per acre each of the two materials.

All efforts should be made to utilise local (garden) supplies of the bulk waste material provided it has a nitrogen content of 0·3 or over and can be collected and applied at a cost (per lb. of nitrogen) not more than that of the bought fertiliser.

Suitable bulk materials are leafy jungle cuttings, cattle and line manure, road scrapings, good forest top soils and even rotted thatch or dhan straw.

It is not necessary to hoe in such bulk material, and if left to rot on the surface, results are as good as when such material is hoed in.

It has been found from actual trials that 8 tons of leafy eupatorium cuttings (withered), maintain a crop equal to that given by 80 lbs. nitrogen as sulphate of ammonia.

It is worth spending up to at least Rs. 13/- per ton in cutting, carrying and supplying leafy jungle cuttings, or line manure.

Forest top soil and road scrapings usually contain not more than 0·3% nitrogen of which perhaps two-third is available. Thus a ton of such soil can be expected to supply about 4 lbs. nitrogen in available form, and an application of 16 tons per acre would supply 80 lbs. nitrogen. Such material is worth applying for in "all-in" cost of at least Rs. 6/- per ton.

In view of the general shortage of fertilisers, (a shortage which is likely to continue for three or four years to come) the following suggestions are made with the object of securing the utmost benefit from the available supplies.

(1) Do not apply manure

(*a*) to areas, the year after cutting back.

(*b*) to young tea under green crops.

(*c*) to any tea over 35 years old with more than 20% vacancies infills and weak bushes.

(*d*) to bushes in the immediate vicinity of mature shade trees or roadsides. As a general rule manures need not be applied to an area about 25 ft. in diameter round a good

shade tree, or to the roadside strip, say 12 ft. width in from the road, which is generally covered by about 3 rows of good tea bushes; these having in previous years reaped the benefit of road scrapings and generally better cultural treatment than the inside of the section.

(2) Manures should be applied broadcast at any convenient time after pruning and before the end of April; in quantities of 40 lbs. nitrogen and upwards per acre. Even at present costs of fertiliser, it always pays to supply up to 80 lbs. Nitrogen on good areas, and generally up to 120 lbs. pays, especially on poorly shaded tea.

(3) Make all possible use of all available waste jungle, line sweepings, road scrapings, cattle manures, straw, old thatch, and rich jungle soil.

OBJECT OF MANURING

The object of manuring is to maintain in the soil a sufficiency of the materials necessary to maintain the growth required to produce a certain level of crop, without detriment to the plant itself. The present position of our knowledge is that after much scientific study and research, both in the laboratory and from the experience gained in the field, the experts have been able to announce certain simple and well attested facts for the general guidance of agriculturists.

YIELD AS A MEASURE OF HEALTH

It is nowadays fully realized that only a healthy tea bush can maintain indefinitely a high output of leaf, and the only true measure of the effect of any factor. such as manuring, on the health of the bush, is its yielding capacity over an indefinite number of years. Any system of manuring which reduces the health of the bush must in time reduce its yield.

COMPOSITION OF TEA PLANT

In order to understand the composition of the tea plant, let us suppose that an entire bush is taken up by the roots. It is chopped into suitable small pieces and weighed, then carefully dried in an oven till all the moisture has been evaporated. Reweighment will then indicate that more than half the original weight has disappeared, as moisture, into the atmosphere.

VOLATILE MATTER

Of the dry material which remains, considerably more than fifty per cent is carbon. This can be transformed into the gas carbon dioxide, by setting fire to the material. With the exception of a tiny pile of ash, the whole of the tea bush has disappeared. Nothing has gone out of existence. The material has been turned into gases and added to the atmosphere as moisture, carbon dioxide, ammonia, nitrogen, etc. These materials which have now become part of the air are the result of the destruction of what is known as the "organic" portions of a plant.

MINERAL MATTER

The little heap of ash contains the "mineral matter" of the plant, and includes potash, phosphoric acid, lime, magnesia, iron, silica, etc., in various combinations, and mostly in minute quantities, the total ash weighing not more than about one or two per cent of the original bush.

It is obvious from the foregoing "analysis", that the tea plant must, like any other plant, absorb a large number of elementary substances in order to make normal growth, and it has in many instances been shown that the absence or defficiency of any one of these substances causes cessation or limitation of growth. The larger part of the solid material of a plant like the tea plant consists of carbon, which is entirely absorbed, in the form of carbon dioxide, from the air by the leaves of the plant. This is converted into a number of substances

called carbohydrates, e.g., sugars, starches, etc., in the leaf, and these are combined with the soluble mineral substances absorbed by the roots from the soil and passed up to the leaves. The complex substances so produced form the material for the new growth.

NEED FOR EFFICIENT LEAF GROWTH

It is thus obvious that even with a liberal supply of all the substances necessary for plant growth, no plant can use these substances and grow satisfactorily unless it is carrying an efficient growth of leaves. Generally speaking, unless all other factors are favourable, a plant will not flourish even with a plentiful supply of food. Conversely, however favourable all other factors may be, growth is inevitably restricted by the amount of plant food available.

MANURES NOT STIMULANTS

It has been a common fallacy to classify soil fertilizers as "artificial" and "natural", or "stimulants" and "foods". Every fertilizer is "artificial" in the sense that it is applied to the soil by man, in order to enrich the natural fertility of the soil, with the object of increasing the yield or quality of a particular crop. No system of manuring which supplies a substance in which the soil is deficient for a particular plant can be regarded as "unnatural".

In recent years the term "artificial manure" has become more or less synonymous with "chemical" or "inorganic manure", as opposed to "organic manure", the latter being of animal or vegetable origin, while the former is in the nature of a salt, capable of being synthesized by a commercial process.

Manures, of whatever origin, must not be regarded as stimulants to plant growth, any more than one would regard bread, meat or vegetables as stimulants to man. A chemical (or inorganic) manure mixture supplies the same plant foods as an organic manure. The only

difference is that the former supplies these foods in readily available form, whereas the organic manure must first be decomposed before its plant food becomes available. *The final form in which these foods are absorbed by the plant is the same whether they come from organic or inorganic manures.*

Oilcake and other organic manures contain nitrogen, potash and phosphoric acid; the nitrogen at any rate is not available to plants as it is locked up in the form of complex substances—e.g., proteins. These decompose in the soil and the nitrogen passes into the form of ammonia. This in turn is converted into nitrates of various salts, and as such is absorbed by the growing plant. In the case of sulphate of ammonia, nitrogen is already in the form of ammonia, which is transformed into nitrates and absorbed by the plant exactly as in the case of organic manures.

LIME

Out of all the many elements required by the plant, only four are, in general, not always available in sufficient quantity in the soil to supply the needs of the average plant. These are nitrogen, potash, phosphoric acid, and lime. The others are normally present in ample quantity in the great majority of soils. Many crops require lime in the soil in large quantities, not so much as a plant food, but because these crops flourish in a soil of low acidity, and lime, being an alkaline substance, reduces the natural acidity of the soil. Tea, however, does best on a soil which is acid, and consequently its requirement of lime is much less than that of many other plants. A crop of 10 maunds per acre takes only about 4 lb. of lime out of the soil, and the great majority of tea soils contain enough lime to supply the requirements of such a crop for a hundred years or more. There is, in fact, not a single case or record where application of lime to tea has been of proved lasting benefit, while no instance is known of tea having been successfully established on a soil which is not acid.

NATURE OF SOIL ACIDITY

The acids responsible for soil acidity are very weak indeed, and are due to the clay and organic matter in the soil.

Part of the organic matter in soils consists of substances of an acid character. Part of the clay portion of a soil is in a state of extremely fine division, the particles being so small as to be indistinguishable even under a microscope. This portion of the clay fraction is termed colloidal clay, and has weakly acidic properties. Part of the organic matter in the soil is in the form of colloidal matter, which has the properties of a weak acid. These weakly acidic constituents of the soil are capable of combining with bases such as caustic soda or lime, forming salts. Soils contain varying quantities of clay and organic matter, and also varying quantities of bases such as lime, potash, soda and magnesia; and the relative proportions of all these soils constituents determine its acidity.

If we apply a base like lime to an acid soil, the latter becomes less acid, or neutral, or even alkaline according to the amount of lime applied. Very stiff clay soils, or soils like the Peat Bheels containing much organic matter, are generally highly acid in nature, and would naturally require large quantities of lime to reduce this acidity appreciably. Sands on the other hand, containing little clay or organic matter, may be greatly reduced in acidity by comparatively small applications of lime.

Though the majority of soils are sufficiently acid for tea, cases exist where the soil is so high in lime or other bases, that its acidity is very low and seriously affects the growth of the tea bush.

The causes of low acidity are:—

(1) The comparative "newness" of the soil, Alluvial soils of recent deposition may contain large quantities of bases. The first attempt to plant tea in Assam was

on a river bank or "chur", near Sadiya. The failure of the attempt might well have been due, in part at any rate, to the low acidity of the soil.

(2) Flooding by water containing bases. Such soils are common in parts of the Dooars, and attempts to establish good tea on these areas have met with failure, until suitable measures have been taken to increase the soil acidity. In the Surma Valley also, floods in 1929 resulted in the deposition of neutral or alkaline silt.

(3) The burning of large quantities of wood or other vegetable matter on the soil. Sites used previously by charcoal burners or occupied by villagers, are commonly low in acidity due to bases introduced into the soil in the form of wood ash, etc. It has sometimes been the practice in clearing forest before planting up a new area of tea, to collect the vegetation into huge piles for burning. The soil of such areas has often been subjected to analysis on account of failure of tea to grow, and is invariably low in acidity.

(4) Application in previous years of large quantities of lime or other alkaline manures. Very large applications of lime, which have been made in previous years, have, on very light soils especially, caused serious harm to young replanted tea.

(5) Continued application of large doses of bulk organic manures such as cattle manure.

(6) White ants. These insects bring up lime from the soil at lower levels, and tea seldom grows on sites previously occupied by white ant "teelas", until the soil has been made acid by treatment with sulphur.

TREATMENT OF UNDER-ACID SOILS

The most effective treatment for soils on which tea is known to be suffering from under-acidity, is sulphur. This treatment is admittedly expensive, but it must be borne in mind that once sufficient sulphur has been added to correct the soil acidity, there is no advantage to be gained from further addition.

The action of sulphur in an under-acid soil is simply explained. With the help of certain types of soil micro-organism, sulphur is converted into sulphuric acid, which is amply strong enough to detach the bases from the weak clay and organic acids.

The resulting salts—i.e., sulphate of soda, lime, potash or magnesia—are subsequently leached out of the soil. Thus the clay and organic acid complexes resume their acid condition.

Sulphate of ammonia has a similar effect; when the ammonia has been converted to nitrate and absorbed by the plant, the residue of free sulphuric acid left combines with and removes the bases from the soil.

It has been suggested that a soil can be made too acid, even for tea, by continuous manuring with sulphate of ammonia. There need however be little fear in this direction, since there are cases of tea growing luxuriantly on soils which have been made far more acid than has yet been met with in nature, or is likely to result from normal manuring. To avoid any possible risk of trouble however, on soils already highly acid, it may be advisable to use calcium cyanamide, an alkaline manure, in rotation with sulphate of ammonia, to maintain a constant level of soil acidity.

POTASH AND PHOSPHORIC ACID

Many experiments have in recent years been done to determine the effect of potash and phosphate manures on tea, both in regard to crop and quality. In general, the effect of these two minerals, either separately or in combination, is very small even after several years of application and is out of all proportion to their cost.

Thus, although 40 lb. nitrogen alone may raise the crop by 4 maunds per acre, at a cost of about Rs. 13-0-0,* a further increase of less than one maund may be obtained from an additional expenditure of Rs. 18-0-0* on manures supplying 60 lb. each of potash and phosphoric acid. In certain cases, as for example on Red Bank soils, potash and phosphoric acid appear to produce much larger increases and the use of manures containing these constituents may be justified on such soils. In general, however, at any rate when only moderate applications of nitrogenous manures are used, there appears to be a sufficiency of potash and phosphoric acid in the soil for the needs of the tea bush. In Ceylon experiments have so far given no indication of any increase from potash, and a very slight crop increase from phosphoric acid manure.

Regarding their effect on the quality of tea, potash appears to lower quality slightly, while phosphoric acid gives indications of producing slightly increased quality. The effects are however very slight and unlikely to be of any practical importance except possibly on gardens making first class quality and flavoury teas. In Ceylon there is evidence of a slight improvement in quality from the use of potash, but none from phosphoric acid. Ceylon teas, however, have normally a much lower potash content than Indian teas and it is quite possible that this may account for the good results on quality reported from Ceylon from the use of potash.

POTASH AND PHOSPHORIC ACID ON YOUNG TEA

On young tea good results have been obtained from the use of potash and phosphoric acid manures. Potash gives increased growth during the first two or three years after planting, while phosphates reduce attack by red spider to a marked extent on young plants. Manures supplying potash and phosphoric acid in addition to nitrogen, are therefore advised for young replanted tea.

* Prewar costs.

POTASH AND PHOSPHATE ON GREEN CROPS AND SHADE TREES

Although potash and phosphatic manures have little effect on mature tea, their beneficial effect on leguminous crops is often very great, especially on soils low in these constituents. The growth of boga medeloa is greatly improved, especially on very acid soils, by an application of a mixture of basic slag and sulphate of potash, which can be hoed into the soil just before sowing. A suitable mixture is 5 parts of basic slag to 2 parts sulphate of potash, applied at the rate of 2 oz. per square yard. As boga medeloa is generally sown in lines, it is convenient to apply the mixture in a strip about 1 foot wide, and 2 ounces of the mixture is thus sufficient for a strip 9 feet long by 1 foot wide. For shade trees also this mixture can be applied at the same rate spread in a wide ring about 10 feet in diameter round the young plant.

MANURES SUPPLYING POTASH

Potash manures include muriate and sulphate of potash, and the minerals kainit and sylvinite. These latter in addition to potash contain soda and other minerals which may actually be harmful to tea, or else are present in ample quantities in tea soils. Muriate of potash is cheaper than sulphate of potash but the chloride it contains is poisonous to plants in large quantities, and for this reason sulphate of potash is preferred except when application is in small doses.

MANURES SUPPLYING PHOSPHORIC ACID

Manures supplying phosphoric acid are superphosphates (ordinary and concentrated), mineral phosphates, basic slag, bone meal, and certain compound manures referred to above, e.g., ammofos and nicifos. Mineral phosphates are sold under various proprietary names and while some are fairly efficient, some are very much the reverse. The superphosphates and certain compound fertilizers such as nicifos are the only ones which are

suitable for tea. The other phosphatic manures are generally either alkaline owing to their high lime content, or economically unsound owing to the high cost per unit of available phosphoric acid; though for green manures, especially on very acid soils, basic slag and the more efficient mineral phosphates prove very satisfactory.

Most organic manures contain either potash, phosphoric acid, or both, and where, as in the case of young tea, these minerals are needed, the use of organic manures containing them is often justified, especially as the nitrogen in such manures is slower acting than that in artificials. This is an advantage in the case of young tea, which may suffer from excessive or careless application of a readily available nitrogenous manure such as sulphate of ammonia. The percentages of potash and phosphoric acid in various manures, both artificial and organic, are given in a table at the end of this chapter.

NITROGEN

The plant (unless it is leguminous) obtains the whole of its supply of nitrogen from the soil, and since dry tea contains over 4½ per cent of this element, a crop of 10 maunds per acre removes annually about 40 lb. of nitrogen from the soil. Add to this, losses of nitrogen from the soil which inevitably result from such causes as, for example, leaching from the soil during the wet weather, and it is not difficult to realize why a full supply of nitrogen has been proved, both by experiment and by experience, to be essential to the satisfactory growth of tea. No soil is devoid of nitrogen, but often much of it is locked up in a form in which it is not available to the plant, so that except on the very fertile soils, nitrogenous manuring is essential if maximum growth is required.

THE NITROGEN CYCLE--ORGANIC MATTER AND HUMUS

As has previously been explained, plants are capable of absorbing nitrogen, only if it is in a soluble form, i.e., as ammonia, or more generally nitrate. In this way

plants differ from animals, which use as food the complex nitrogenous substances (proteins) built up by plants from the simple nitrates. This protein is returned to the soil by the excreta of animals, by their bodies when they die, and by the leaf fall and natural decay of plant life. In the soil this animal and vegetable matter is acted on by the various soil micro-organisms, which split up the protein substances, producing ammonia and then nitrate, thus providing plant food in suitable form. This cycle of changes, beside providing plants with their essential food nitrogen, in available form, also maintains a supply of organic matter in the soil. The plant, besides absorbing nitrogen and other substances from the soil, has taken in carbonic acid from the air and converted it into carbohydrates, e.g., sugars, starches and cellulose. These go partly to form the fibrous and woody portions of the plant, and when vegetable matter rots in the soil, these carbohydrates become decomposed and the woody portion combines with protein to form what we know as humus. Thus humus forms a store of nitrogen in the soil; in addition it helps to maintain the soil in good physical condition, and in certain circumstances, more resistant to drought effects.

It is thus easy to see that a soil left to itself to accumulate organic matter from leaf droppings and decay of plants will in time become rich in humus. Further, if as is normally the case, much of the vegetation growing and dying on the land is of the leguminous type which can take its nitrogen as well as its carbon from the atmosphere, the soil will be increased in nitrogen and consequently in fertility.

Cultivation of a soil greatly assists the break-down of humus, setting free nitrogen as soluble nitrates, and hence large crops can be taken from a rich virgin soil by intensive cultivation. In time, however, if the removal of nitrate by crop is not made good by artificial means, the soil loses its fertility and cropping capacity. Not only so, but much of the excess nitrate set free by cultivation and not taken up by the plant is leached out of the soil and lost.

Although a rich soil may be converted by intensive cultivation and cropping into a poor infertile one, it will still maintain sufficient fertility to produce a tea crop, small though it may be. In practice it is found that tea will produce on almost any soil, about 5 maunds per acre unmanured.

EFFECT OF NITROGEN ON TEA CROP—SECONDARY EFFECTS OF MANURES

Such tea, assuming that it is suffering only from shortage of plant food, and not because it is full of vacancies, or attacked by disease, responds very readily to an efficient nitrogenous manure. The response will not of course be obtained in full, in the first or even the second year of manuring. In fact it will normally take at least four years to raise the crop to a steady level. The increase will depend on the quantity and efficiency of the manure, and is in the case of annual application of sulphate of ammonia, about 1 maund of tea for every 10 lb. of nitrogen, or 50 lb. of sulphate of ammonia. With cattle manure, the response is normally about $\frac{1}{2}$ maund of tea for every 10 lb. of nitrogen, and in the case of an average sample of this manure, it would require about 1 ton of manure to supply 10 lb. nitrogen. Nitrogenous manures vary in the efficiency of their nitrogen, and a manure which may be efficient for tea may be inefficient for other crops, due to secondary causes. Thus, for tea, sulphate of ammonia has proved the most efficient nitrogenous manure and there is no doubt that its valuable secondary effect in increasing soil acidity has something to do with this efficiency. On a crop which thrives best in a low-acidity soil, this secondary effect of sulphate of ammonia might well prove harmful instead of beneficial and an alkaline manure such as calcium cyanamide might prove the more efficient.

VARIOUS FORMS OF NITROGENOUS MANURES

This brings us to a consideration of the various forms of nitrogenous manures available for application

to tea. In the table at the end of this chapter, the costs per ton, percentages of nitrogen, potash and phosphoric acid, and the unit costs are given. The figures for the nitrogenous manures in this table are taken from the Indian Tea Association's publication "The Nitrogen Supply to Tea" by H. R. Cooper.

It will be observed that some of the nitrogenous manures are inorganic while others are organic. Of the organic manures, some, like rape-cake, are of vegetable origin while others, like horn meal, are of animal origin.

It is at once apparent, even assuming that the nitrogen in all these manures is as efficient for tea as that of sulphate of ammonia, and that such potash and phosphate as they contain is worth paying for, that the organic manures generally are more costly, on the unit basis, than the inorganics. Actually, experiments show that not only is the potash and phosphoric acid not generally worth paying for, on mature tea, but that the organic manures contain nitrogen in less efficient form than that in the inorganics. These facts still further enhance the high cost of the organics in comparison with an inorganic like sulphate of ammonia.

ORGANIC VERSUS INORGANIC MANURES

This leads us to the question of the relative merits of organic manures as opposed to inorganic. Granting the fact that whichever form is used, they both provide in the end the same form of nitrogen to the bush (i.e., soluble nitrate), is there not some value apart from nitrogen supply, to be attributed to organic manures which inorganics do not possess? We know that soils rich in humus are normally more fertile than those low in humus, and that humus is continually being lost by cultivation of a crop on a soil. We are often told that this loss must be made good by application of organic manures, or the soil will lose its fertility and become a mere wind-blown sand. Even if this is true of other crops it is certainly not true of tea. Areas which have had nothing but artificial mixtures for 20 years are still

carrying excellent tea, and the soil, far from being infertile, is as rich in organic matter and nitrogen as similar areas which have had nothing but organic manure. The reason is not far to seek ; tea producing a steady annual crop of 10 mds. per acre (800 lb.), gives, annually pruned, about 4 tons of prunings which are turned into the soil. The higher the crop, the greater the weight of prunings, other things being equal. The organic matter in 4 tons of prunings amounts to a little under $1\frac{1}{2}$ tons, which has come from the air and is thus direct addition of organic matter to the soil.

The continual application of organic matter in the form of prunings, and the leaf fall of shade trees and green crops, which are commonly grown amongst tea, has the net result not merely of maintaining but often of increasing the humus content of the soil. The difference therefore in the state of affairs in tea soils and in those soils growing annual crops which are entirely or almost entirely removed from the land, e.g., root or cereal crops, is easily seen; and the relatively small importance of organic manures in tea can be appreciated. So long as the nitrogen supply to the tea bush is maintained the organic matter in the soil "looks after itself", if other cultural methods are intelligently followed.

CONCENTRATED ORGANIC MANURES

In any case, the amount of organic matter normally applied to the soil by such concentrated organic manures as oilcake or blood meal is too small to be of any assistance in maintaining humus in the soil. The difference between inorganic manures and such concentrated organic manures as oilcake, etc., lies in the rate at which the nitrogen they contain becomes available, as nitrate, to the plant. Organic manures are slow acting in comparison with inorganic, though the difference is much smaller under conditions of high soil temperature and rapid decay than it is in temperate and cold climates. Moreover in the case of a perennial crop like tea, a manure which is so slow acting that its full effect is not

produced in the first year of application exerts a residual effect in the second and possibly subsequent years. Thus after some years of regular annual application the net result is the same as in the case of a quicker acting manure.

Where large applications of manures are being made, as in the case of market gardening, damage may be done to the delicate tissue of a young plant by the sudden introduction of a large quantity of highly efficient nitrogenous manure such as sulphate of ammonia. On the other hand, an overdose is hardly possible with an organic manure in which the nitrogen is only slowly made available.

With the exception of the manuring of young plants, it is hardly likely that sufficiently large quantities of artificials would ever be applied in commercial practice to tea, to cause damage. Certainly no harm has occurred to mature tea from applying four times the quantity of sulphate of ammonia normally used.

Young tea however, is adversely affected by large dressings of inorganic manure, and unless supervision of the application of inorganics is very efficient, it may be the safest policy to use only such manures as cattle manure, composts, or oilcake until the tea is about three years old.

Generally speaking however, the use of concentrated organics is an unsound policy in tea unless they can be obtained at very much lower costs than those ruling at the present time.

BULK ORGANIC MANURES

Organic manures can be classed as :—

(*a*) Concentrated ; e.g., animal meal, oilcake, etc.
(*b*) Bulk ; e.g., cattle manure, compost, jungle or green manure cuttings, etc.

The latter forms of organic manures merit considerable attention, since they can often be obtained locally and applied at a cost comparable with that of the cheap inorganic manures.

Though in general, tea yielding well and covering the soil has no need of addition of organic matter from external sources, there are cases where if sufficiently large applications are made, bulk organic manure can prove of great value. Such cases are young tea replanted on a worn-out soil; poor tea, especially on stiff poor soil or on washed slopes; and cut back tea.

The addition of large quantities of organic matter may render the soil more resistant to drought and improve its tilth.

The application must, however, be very large to make any appreciable difference to the soil in these directions. Five tons per acre is equivalent to less than $2\frac{1}{2}$ lb. per square yard, which is a very thin spread. A good average sample of cattle manure contains not more than 15 per cent organic matter, so that a 5 ton per acre application supplies only 15 cwt. of organic matter. This can make little difference to the soil's humus content, unless it is applied annually for a large number of years. It is the common practice among market gardeners and horticulturists to apply as much as one or two hundred tons of farmyard manure per acre to their crops, and to maintain an annual application which, not perhaps as high as the initial dressing, is much higher than would be economically possible in tea. The crops removed are sometimes many hundred times the weight of the crop removed from an average tea garden, and there is little or nothing returned to the soil from the crop, as in the case of tea when its prunings are hoed in. Thus the use of these enormous applications of manure may well be justified in the case of the market garden.

The valuable properties claimed for bulk organic manures like cattle manure and humus composts are :—

(1) Slow action; this avoids the risk of overdosing on young tea, referred to previously.

(2) Improvement in soil tilth and drought resistance; these are valuable assets where nurseries and replanted tea on worn-out stiff soils are concerned.

(3) Encouragement of root formation; there is evidence that cattle manure and compost contain substances, some of them akin to vitamins, which are of value to young plants in that they encourage the formation of roots. Many of these "auxiliary food factors" can actually be obtained in a concentrated form and have been used to encourage the rooting of cuttings of various plants. They are on the market under various proprietary names, and are actually chemical compounds which have been synthesized from simple substances. The presence of such substances in cattle manure and composts makes these manures of especial value to young plants, and the practice of applying well-rotted cattle manure or compost to nurseries and old tea land at the time of planting of the young tea, is an excellent one.

BULK ORGANIC MANURES FOR NURSERIES

It is essential however, that the manure used for nurseries and young tea shall be well rotted. For nurseries the application should not be less than 20 tons per acre, while with very poor soils, especially if stiff and in poor tilth, 50 tons is not excessive. It should be well hoed in about three months before the time of planting the nursery, and the site hoed over lightly three or four times during the interval to make sure that any weeds which grow from seed mixed with the manure, are destroyed. One of the objections frequently advanced against cattle manure and such like material is that its application results in a tremendous growth of weed. If the manure is really well rotted, however, jungle seeds are destroyed in the process of fermentation.

If a large dressing of manure is given, it is essential that it is hoed in to a depth of at least a foot, otherwise the roots of the plant remain in the shallow layer of rich

surface soil and the plants are liable to suffer from subsequent drought. The early application of the manure and subsequent hoeing of the soil prior to planting ensures decomposition of most of unrotted portion of the manure and reduces the liability of cricket damage after the nursery has been put out. Crickets are attracted by unrotted and partially rotted vegetable matter in the soil. "New" manure should never be used for young plants as, apart from the jungle seeds it contains, there are eggs and larvæ of all kinds of insects which may do damage to the plants.

BULK ORGANIC MANURES ON YOUNG TEA

In the case of replanted tea it is usual to mix about 10 lb. of the manure with the soil which is being filled in round the plant. The manure should not be placed at the bottom of the hole, as when it rots it is liable to leave a cavity under the plant. Later the plant sinks and a depression is formed round the collar which results in the plant becoming waterlogged.

BULK ORGANIC MANURES ON MATURE TEA

On mature tea, cattle manure has an effect which is about half what one would expect from its content of nitrogen, in comparison with the effect obtained from an efficient artificial manure. Thus, the annual application of good cattle manure gave an increase in crop of about half a maund of tea per 10 lb. nitrogen supplied by the cattle manure. On similar tea, sulphate of ammonia was giving an increase of one maund for every 10 lb. nitrogen applied. These increases were those obtained after 8 years of continuous application of the manures, when steady crops were being obtained, and when the residual effects of both manures were in operation, along with their immediate effects. Actually, experiments show that for mature tea, cattle manure is no longer lasting than the supposedly "quick acting, short lasting" artificials.

It is thus quite clear that no especial benefit can be attached to the use of cattle manure on mature tea, which cannot be obtained with artificials. If a garden is so fortunately placed that it can obtain and apply large quantities of good cattle manure for a cost of not more than Rs. 10 per ton, it is well justified in using such manure even for mature tea, though it is of course obvious that all young tea nurseries and infillings will have prior claim. On most gardens it is considered that the cleaning of lines, etc., is an essential garden work. The waste material so collected, and known as line manure, consists of a good deal of soil, soaked with cattle urine and mixed with cattle manure, straw, thatch and other vegetable matter. This may be stored in pits and mixed with any other waste material convenient to hand, such as old thatch of coolie houses, rice straw, etc., and left to rot, when it can be applied as manure to conveniently adjacent sections.

It is common to throw all waste line manure on to the nearest section, which thus gets an ample supply of manure. Unfortunately when organic manures decompose in the soil they leave a residue which is alkaline and may in time cause a soil to become too low in acidity to grow good tea. If tea so generously treated with line manure is found to be growing poorly it is advisable to get the soil tested for acidity. Under-acidity can then be corrected by an application of sulphur.

HUMUS COMPOSTS

Attention has in recent years been directed towards the possibilities of using all kinds of waste vegetable material as manure for crops. It has been explained earlier in this chapter that organic vegetable and animal matter contains nitrogen locked up with the carbohydrates in the form of complex compounds, and that for the nitrogen to become available to the plant, decomposition of the carbohydrate by micro-organisms must take place. These micro-organisms, fungi and bacteria, themselves require as food, soluble nitrogen, while they are doing

their work of decomposition. The soluble nitrogen they absorb is later set free again when the organisms have completed their work and themselves decompose. If we take a material such as straw or thatch, and add to it the requisite organisms, they are unable to proceed with the work of decomposition unless they are supplied with a "starter" in the form of a supply of soluble nitrogen. The reason that thatched roofs rot in time, though extremely slowly in temperate climates, is that certain micro-organisms naturally present, convert nitrogen from the atmosphere into soluble form, and with suitable conditions of moisture and temperature, rotting goes on.

If thatch or similar material is hoed into a soil, the micro-organisms use up soluble nitrogen naturally present in the soil while breaking down the organic material. Any plant growing on the soil is thus likely to be temporarily starved of nitrogen until the organic matter has been broken down. When this has happened, the soluble nitrogen is again restored to the soil and can be then used by the plant, if it has not died of starvation meantime.

It is for these reasons that the application of very large dressings of unrotted vegetable matter to a soil carrying a crop, is not advised. Much depends, however, on the nature of the crop and the nature of the vegetable matter to be applied.

Straw and thatch and woody parts of plants contain a low proportion of nitrogen to carbohydrate, and decomposition requires a considerable amount of soluble nitrogen from an external source. The leafy parts of many plants however, contain a much higher ratio of nitrogen to carbohydrates, and break down with little or no addition of soluble nitrogen. It does no harm (even temporary) to the growing tea-bush if comparatively large quantities of leafy material of this nature are hoed in.

In order to avoid the depressing effect on crops due to decomposition of large quantities of organic matter in the soil, the system of composting has been evolved,

and in recent years elaborated in great detail. It consists in mixing the waste vegetable matter with a supply of soluble nitrogen, and adjusting conditions so that rapid decomposition of excess organic matter shall take place, producing a material which can be applied to the soil in readily available form. The various methods of composting have been described in detail in many recent publications, and only the main features of these processes are described here.

INDORE COMPOST

The system developed in the State of Indore is one which is particularly suitable to the needs of the cultivator in India. Waste vegetable material of all kinds is mixed with cattle manure and wood ash, and the source of available nitrogen is cattle urine, or urine-impregnated earth from cattle sheds or pens. The urine contains soluble nitrogen in the form of ammonia compounds. The mixture is allowed to ferment in shallow pits, and turned over at intervals to aerate the material, and after about three months the material should be sufficiently broken down to be used as manure. There is a rise in temperature, due to heat of fermentation, which is usually highest (about 150°F.) about three weeks after the start.

ADCO COMPOST

In the preparation of another form of compost, the source of available nitrogen is the proprietary substance "Adco Patent Starter" containing, in addition to available nitrogen, potash and phosphoric acid. It is alkaline and provides the correct condition of alkalinity required in the composting process. In the Indore and other similar processes, wood ashes are relied on to supply the required degree of alkalinity.

Other "starters" which may be used in the composting process are calcium cyanamide, sulphate of ammonia, and in fact any soluble nitrogenous manure.

provided sufficient lime is also added, when necessary, to maintain an alkaline condition.

Another process, called the "Dacca" system, makes use of the fertilizer "nicifos" (see table at the end of the chapter). This process is designed for use where the sources of vegetable matter are scattered, and not conveniently close to supplies of cattle manure, etc. Leafy jungle is collected in heaps conveniently close to tea areas, e.g., around the jungle edges of the estate, and mixed with road scrapings and nicifos. The latter is required in small quantity only, roughly 2 lb. for every ton of vegetable matter.

There are other processes, such as the Lincoln process, in which the cowshed or pen is used as the site for the composting process. A layer of rammed earth is first placed on the floor of the shed and is covered with straw as bedding, and when necessary more bedding is added. Before the level of the floor becomes inconveniently high, the rotted bedding is removed, together with the dung and the under layer of urine-impregnated earth, and this mixture is used as manure; its place being taken by fresh soil and bedding.

COST OF COMPOSTS

Costs of composting waste material vary enormously in the tea districts of North-East India. It is possible, indeed, to work out the cost to almost any figure, depending on what items are included. It is, however, fair to omit any charge which would normally have been necessary had composting not been done; e.g., cutting of jungle edges, cleaning of roads and lines, etc. It is a difficult matter to estimate accurately the weight of compost made; impossible to weigh actually every ton made, while calculations based on cubic capacity depend entirely on the amount of water, woody and unrotted stuff and soil included in the material and counted as true compost.

It is obvious that the only true measure of the value of a compost for tea is its effect in the field, compared

with some manure whose efficiency is known. Experiments have been in progress for ten years or so on various estates in North-East India, and none so far indicate any greater efficiency from composts, whatever their mode of preparation, than that of a good average cattle manure. The latter has been shown to have an efficiency of about half that of an efficient artificial supplying the same quantity of nitrogen. Results over a long period may supply evidence of greater efficiency than that obtained at present for bulk organic manures, but at the present time the indications are against its indiscriminate use in tea.

Where these manures can be obtained and applied for a cost not exceeding about Rs. 2 per ton, their use even on mature tea is justified. For young tea, as has previously been explained, their value is much greater.

USE OF WASTE VEGETABLE MATTER WITHOUT COMPOSTING

The use of easily decomposed vegetable matter such as green jungle cuttings, applied direct to the soil, has long been advocated and practised in many tea estates, more particularly on hill gardens. The method used was to bury the green jungle in trenches a foot or so deep, or to use it as a surface mulch on the soil. The latter method is much to be preferred, especially in districts liable to drought.

More recently, experiments have shown that jungle cuttings hoed into the soil, together with a soluble nitrogenous manure such as nicifos, have given results as good as, and even better than those obtained by application of composts prepared from the same or similar materials. Provided there is ample green leafy material in the stuff applied to the soil, much of the nitrogen becomes available quickly and tea actually responds in a remarkably short time. The supply of available nitrogen appears to be ample for the needs of the tea, and also for the micro-organisms which decompose the more

resistant vegetable matter. No set-back to mature tea, either temporary or otherwise, can be detected even when as much as six tons of leafy *Eupatorium* ("Giant Ageratum") cuttings are hoed into the soil, in the late spring, without any addition of soluble nitrogenous manure such as nicifos. This being so, one of the main reasons for composting disappears, and some very special advantage in composting must be proved in order to justify such an elaborate process in preference to direct application of uncomposted vegetable matter. It must also be borne in mind that much nitrogen, as well as organic matter, is lost in the composting process. No doubt some of the nitrogen in vegetable material is also lost when this material is applied direct to the soil, but comparative results indicate that the loss is much less than that sustained by composting.

On estates which have literally miles of jungle edges, as in the case of many Cachar and Sylhet gardens, the cutting of these edges is often regarded as an essential routine. The application of the withered leafy cuttings so obtained, direct to the adjacent tea areas, could generally be done for a comparatively small cost, much less certainly, than that of composting them before application.

On south slopes of "teelas", and on other areas liable to suffer from drought, the mulch formed by an application of cut jungle at the rate of 5 to 10 tons per acre, without hoeing in, proves invaluable in preventing evaporation of moisture from the soil. There is of course risk of fire in leaving prunings and dry jungle unburied on the surface of the soil, but this risk can to a great extent be reduced by leaving fire-lines of clean hoed soil, and by the employment of good chowkidars on the garden.

TOP DRESSING WITH PEAT SOIL

Many gardens have at their disposal areas of low lying peaty soils, which are often very rich indeed in nitrogen and organic matter. It is often profitable to use these peaty deposits for top dressing, especially on

areas of poor soil, such as slopes which have suffered soil wash. Care should however be taken to ensure that the peat soil so used is amply acid, and really is as rich as it appears to be. Many deposits are deceptively black and rich looking but may contain little more nitrogen and organic matter than the soils which they are intended to enrich. A good rich acid peat soil is well worth applying to adjacent tea land providing the application cost is not more than about Re. 1 per ton. An application at the rate of about 10 tons per acre is the minimum likely to be of appreciable benefit.

TIME OF YEAR FOR MANURING

It has been shown that the time of the year when manures are applied makes little or no difference to crop, after manuring has been going on for a few years and yields have settled down to a steady level. The most convenient time however on most gardens for the application of manures, is in the months of February, March or April when labour is generally available. It has been thought that better quality second flush teas might be made if manures were applied either after the second flush, or at least in divided applications. While this may possibly be so in the case of gardens making very flavoury teas there is no definite evidence in favour of delaying manuring till after the second flush. In fact, it appears to make no difference to average good Assam second flush teas whenever the manures are applied, or whether they are applied in single or divided doses. The divided doses also give the same total crop over the whole season as a single dose, even when the rate of application of manure is large.

With young tea it is better to delay the application of manures until the plants are growing vigorously. It is known that sulphate of ammonia has an initial depressing effect lasting about three weeks, and its concentration round a young plant at a period of the year when it is carrying little leaf and is likely to be weak, would have a temporary bad effect, which would be

obviated by application of the manure at a later period, e.g., June or July, when the plant is growing vigorously.

METHOD OF APPLICATION

For young tea in its first year of planting it is best to apply the manure in a ring round the plant; about 18 inches outside and 6 inches inside diameter, taking care that no manure is spread close to the stem of the plant. In the second and third year the circle may be widened so that its diameter corresponds roughly with the spread of the plant. In the fourth and subsequent years the manure should be broadcast in the same way as for mature tea.

The application of manures is an operation which well pays for good supervision. Evenness of spreading is very essential, and small receptacles, such as cigarette tins, should be used for measuring out the quantity to be spread over a certain area. It is useful to know that an ordinary size cigarette tin holds just 10 ounces of sulphate of ammonia, if well shaken down. This, at an application of 200 lbs. per acre, is enough to cover 15 square yards (or roughly the area occupied by 8 tea bushes if planted $4\frac{1}{2} \times 4\frac{1}{2}$ triangular).

On areas which contain many vacancies it is of course a waste to apply manures to the empty spaces of soil. The only result is the encouragement of weed growth which has to be suppressed by continual cultivation.

HOEING IN OF MANURES

Soluble artificial manures do not require hoeing in after application. Unless the soil is dry and there is a very high wind immediately after application, the manures remain on the surface until carried into the soil by the next shower of rain. If the soil is moist at the time of application, or if there is dew at night, the manures are partially or completely dissolved and "fixed", so that they do not blow away in a wind.

Experiment and practice have shown that organic and mixed organic and inorganic manures do not need to be hoed in, on flat or gently sloping land, if applied at the usual time, i.e. during the period of dry weather, or during the period when gentle showers are to be expected. On sloping land, where soil wash may be considerable, it is advisable to fork hoe manures, organic and inorganic, after application.

HEAVY PRUNING AND MANURING

It has been found that a bush which is medium or heavy pruned requires no nitrogen in addition to that which it can get from the soil, for some time after pruning. After a normal cutting back, little leaf is left on the bush, and until sufficient new growth of leaf has been made the bush takes little from the soil, the growth being obtained from such reserve as the root and frame contained at the time of cutting back. Manuring of cut back tea can therefore be delayed until there is sufficient leaf to make use of the manure. In North-East India, the cutting back of a bush generally is necessary at intervals of not less than 15 years; often, especially in the case of tea unpruned in alternate years, the interval may be extended to 25 years or more. Little or nothing in the way of crop is expected in the year of cut back, the sole object being to help the bush by allowing it to make plenty of new growth. This it can do if it is very lightly plucked, and in view of the fact that little or no crop is taken, no manure need be given. It is better to save the manure till the year following, when an extra supply can be given which the bush is then capable of using.

It is often stated that potash is required by heavy medium pruned tea in order to enable it to make good wood. Whether any advantage results from application of potash to cut back tea is at present unknown and it is a matter on which accurate experimental evidence is required.

MANURING OF SEED TREES

Little is known in regard to the manuring of tea-seed trees, but the general experience of seed growers and the results of experiment on other fruit and seed crops indicate that both nitrogen and potash are required. Nitrogen is undoubtedly required, many seed gardens showing very obvious signs of nitrogen deficiency in the dying back of branches and general debility and disease. It is often thought that what is needed in these cases is a thorough prune, and trees are cut back even to the point of collar pruning, when what is really needed by the tree is plant food.

Cattle manure if available is a suitable manure, containing as it does, nitrogen, potash and phosphoric acid; it may be applied at the rate of up to two maunds per tree per annum, preferably in two applications, one of 30 seers in the spring, e.g., early May, and another 50 seers in early September.

If cattle manure is not a available or is too expensive to apply, the following artificial mixture is suitable:—

8 parts of sulphate of ammonia.
3 ,, ,, ,, ,, potash.
1 ,, ,, concentrated superphosphate.

This mixture should be applied to mature trees at the rate of 1 lb. per tree in early May, and a second application of 2 lb. per tree made at the beginning of September. Manures for seed trees should be spread evenly in a large ring round each tree, about 3 feet inside, and 12 feet outside diameter, and lightly forked in.

THE EFFECT OF MANURES ON THE QUALITY OF TEA

Little was known about the effect of manuring on the quality of tea until recent years and even now our knowledge is a long way from being complete. The following are the conclusions drawn from experiments carried out by the Scientific Department of the Indian Tea Association and a few commercial concerns in Assam, and by the Tea Research Institute in Ceylon.

(1) Nitrogenous manures affect quality adversely, though to a very small extent, and then only if used in sufficient quantity to produce very large crop increase. For instance, out of twelve tea-tasters who examined teas made from unmanured areas, and areas which had for several years had annual doses of 200 lb. of sulphate of ammonia per acre, none could detect any difference due to manuring, nor could it be said that the combined verdict of all twelve tasters was definitely in favour of the unmanured tea, which was yielding at the rate of 7 maunds per acre compared with 10 maunds per acre for the manured tea.

(2) Similar tea manured for the same time with 400 lb. of sulphate of ammonia, and yielding over 14 maunds per acre gave very slightly poorer quality. This loss in quality was not detected by any single taster but only by taking the combined opinion of all twelve tasters.

(3) Organic manures have the same effect on quality as inorganics.

(4) Potash manures have either no effect on quality or a very slight adverse effect, in Assam. In Ceylon the tendency is for potash to improve liquors slightly. Assam teas are however normally high in potash content while Ceylon teas are comparatively low in this constituent.

(5) Phosphoric acid manures in Assam have either no effect or have a very slight good effect on quality. In Ceylon no effect has been observed.

(6) Lime has no effect on quality.

(7) Very heavy sulphur applications, sufficient to make the soil extremely acid, appear to reduce quality slightly.

Manures have often been blamed for loss in quality which is in reality due to some other factor. If for example manuring produces such an increase in crop that it is impossible to maintain the previous fine standard of plucking with the labour available, quality will fall off. This is due, however, not to manuring but to coarser plucked leaf. If larger crops are to be made, not only must the standard of plucked leaf be kept up, but factory conditions must be adequate to deal with the increased crop, or again quality will suffer. As far as the effect of manuring itself is concerned however, providing all other factors are kept constant, manuring to maintain a crop of up to 12 maunds per acre will in the plains, result in extremely little if any loss in quality. Drop in quality from manuring to give more than 12 maunds per acre is likely to become noticeable, especially on quality gardens.

ECONOMICS OF MANURING

When crops are unrestricted, and the market paying good prices for tea, manuring under practically any circumstances must pay handsomely.

As mentioned previously, the supply and range of manures available to the Tea Industry is restricted, and is likely to be so for the next 2 or 3 years. However it is hoped that things will in time return to normal, as in pre-war days, and the following observations and tables have been left unchanged from the previous edition.

It has already been shown that an area of unshaded tea on an average soil will drop to a steady 6 maunds per acre or thereabouts if unmanured, but will maintain a yield of about 10 maunds per acre if annually manured with 200 lb. sulphate of ammonia. This extra 4 maunds per acre may cost say, Rs. 60, to place on the market (plucking, manufacturing, boxing, freight, etc.). To this must be added the cost of the manure—Rs. 13 including freight. Four maunds of tea, at a cost of Rs. 73, works out at a little over $3\frac{1}{2}$ annas per lb. Thus, unless the price of tea falls to this level, manuring shows a profit.

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Under restriction the question is more complicated; e.g., in the case of a well-shaded garden able to make its restricted crop without difficulty, money may easily be wasted on manuring. The economic position must be carefully worked out for each individual case, taking into account labour and factory conditions, as well as other factors such as climate, market, etc. In a later chapter the relationship between the various cultural and manufacturing factors and the economics of the production of tea is dealt with in greater detail. In general it may be said with regard to manuring that the application of 40 lb. of nitrogen over a small area annually will allow of a garden's restricted crop being made more cheaply (and with no appreciable loss in quality), than the same crop from a larger area unmanured. In certain cases, e.g., to improve poor patches of tea, heavier dressings of manure may be required temporarily; but it must be realized that a small loss in quality is likely to result.

UNIT COSTS OF NITROGEN, POTASH AND PHOSPHORIC ACID BASED ON PRE-WAR PRICES

	Analysis of manures.			Cost per ton delivered.	Unit cost	
	Nitrogen, per cent.	Phosphoric acid, per cent.	Potash, per cent.		If valued for nitrogen only.	Allowing for any other constituents.
Inorganic manures :–				Rs.	Rs.	Rs.
Sulphate of ammonia ...	20·5	...	...	111	6·8	6·8
Calcium cyanamide	19	...	...	129	6·8	6·8
Nitrate of soda	15·5	...	...	152	9·8	9·8
Nitrate of potash	9	...	33	172	19·1	7·6
Nicifos	18	18	...	191	10·9	6·3
Ammophos	16	20	...	186	11·6	6·4
Concentrated organics :—						
Oilcake, rape (local)	4·5	2	1	52	11·6	8·9
,, castor (Calcutta) ...	7	2	1	92	13·1	11·5
,, ground nut (,,) ...	6	2	1	90	15·0	13·0
Nervox (sinews and hide) ...	10	5	...	127	12·7	10·5
Horn meal	11	2	...	162	14·7	13·9
Dried blood	11	...	...	197	17·9	17·9

UNIT COSTS OF NITROGEN, POTASH AND PHOSPHORIC ACID BASED ON PRE-WAR PRICES—(*Contd.*)

	Analysis of manures.			Cost per ton delivered.	Unit cost	
	Nitrogen, per cent.	Phosphoric acid, per cent.	Potash, per cent.		If valued for nitrogen only.	Allowing for any other constitutents.
Fish guano	7	7	...	157	22·4	18·1
Animal meal	7	7	...	167	23·7	19·6
Manures supplying potash or phosphoric acid :—	...	...	...	...	Unit cost of potash or phosphoric acid.	
Sulphate of potash	...	...	49	167	3·4	
Muriate of potash	...	...	51	157	3·1	
Kainit	...	...	19	117	6·2	
Ordinary superphosphate ...	...	19	...	102	5·4	
Concentrated do.	...	42	...	172	3·9	
Basic slag	...	17	...	87	5·1	
Algerian phosphate	...	31	...	97	3·1	
Belgian flour phosphate ...	...	19	...	72	3·8	
Seychelles guano	...	27	...	102	3·8	
*Bone meal	3½	21	...	112	5·3*	

* Including its nitrogen valued at Rs. 6-8 per unit, the unit cost of bone meal is Rs. 4·2.

CHAPTER VII

SHADE TREES AND GREEN MANURING

LEGUME BACTERIA

It is not many years since green manuring was taken to mean only the ploughing in or hoeing of green stuff into the ground, with a view to fertilizing the soil for a crop to follow. Now, however, the expression has a wider signification, and is taken to mean also the planting of shrubs and trees, to act as perennial fertilizers amongst the particular crop which is cultivated. It is now very generally known by agriculturists that most leguminous plants, trees, and shrubs, viz., those which carry their seeds in pods, have the faculty of fostering upon their roots certain bacteria, which by their activities absorb free nitrogen from the surrounding atmosphere, and transform it into nitrates in which form it is readily available for the support of plant life. It has been demonstrated that the special usefulness of certain crops for green manuring and the fertilizing properties of leguminous plants and trees, are directly traceable to the presence of these bacteria upon their roots.

LEGUMINOUS PLANTS IN TEA

All plants used nowadays as shade trees or as green crops in tea belong to the legume family. Thus by growing legumes on a soil and hoeing them in when mature, the soil is thereby enriched in available nitrogen and its fertility is increased. Hence the term "green manuring", applied to the practice of growing legumes as cover crops and hoeing them into the soil.

Many years ago in tea the practice of growing leguminous trees among tea bushes was started, and the original object was not primarily that of providing shade but of obtaining the benefit of the leaf droppings from

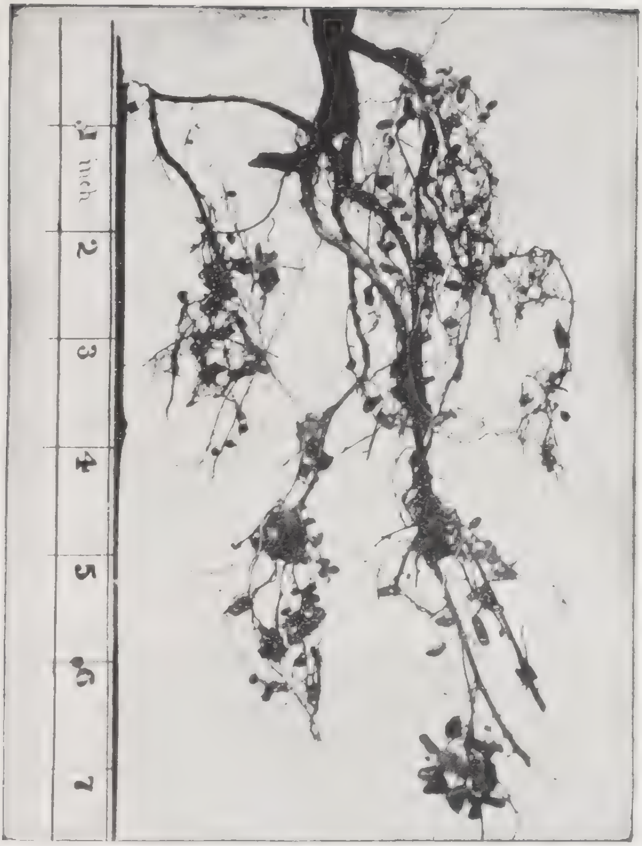
these trees. Nowadays the purposes of shade trees and green crops are considered to be :—

(1) To manure the soil and to improve its tilth.
(2) To supply shade.
(3) To reduce soil wash.
(4) To suppress weed growth.
(5) To act as wind brakes and protection against hail.

TYPES OF SHADE TREES IN COMMON USE

In North-East India the commonest shade tree is *Albizzia stipulata* known as the "sau", or black "siris". This was the first type of tree to be used in North-East India as a shade tree in tea; though it was primarily intended to act as a green manure. The following account of the early use of the sau tree is taken from "The Pests and Blights of the Tea Plant" by George Watt, Calcutta, 1898.

"Several years ago Colonel Hannay (in Dibrugarh, Assam) called attention to the value of the 'sau' tree and gave it the name of the tea fertilizing tree. The 'sau' tree is *Albizzia stipulata* of botanists, and belongs to the sub-order Mimosæ of the Leguminosæ. To Mr. J. Buckingham belongs the honour of having prominently drawn attention to the value of the 'sau' tree. Several experiments were made by him which went to prove that 'sau' possessed peculiar properties in bringing round exhausted soils and causing the bushes to flush vigorously, while imparting a vitality of which old tea was deficient. On the 23rd October, 1884, Mr. Buckingham published, for the benefit of the Indian Tea Association, a little pamphlet on this subject which gave his own experience and that of several planters regarding the 'sau' tree. Shade is not usually the cause of an increase of yield, and is in fact condemned by the generality of planters, as it tends to make the bush throw out long stalky shoots and thus to produce poor and woody flushes; such, however, can hardly be said to be the case when 'sau' is employed. The tea bushes under that tree have been reported by



Bacterial Nodules on Roots of *Boga Medeloa*.

Leaves and Fruit of Siris Tree.
(*Albizzia Stipulata*).

those who believe in it to yield a considerably higher amount in a given area than in any other part of the garden, under similar conditions of soil and age of bush. It has been observed that tea grown under 'sau' enjoys a considerable immunity from blights and pests, while the surrounding trees are suffering badly.

"The action of the 'sau' was attributed by some to the beneficial shade which it casts over the plants; others considered that it was the manure furnished by the dead leaves; a few thought that the advantage of interplanting the trees was the fact that the roots went to a greater depth than the tea roots, and drained the superabundant moisture from the surface soil, while, on the other hand, they brought up from the sub-soil food material for the tea plants. Mr. Buckingham remarks, 'I do not wish to contend that "sau" is capable of improving tea plants where the soil contains elements which in some instances nature has abundantly supplied for the support of the bush, but I do assert that the vitality of the tea bush is limited probably in a great measure depending on the character of the soil, and unless we restore some of those essential parts we are yearly, I may say weekly, abstracting, the tea-planter in a few more years may be surrounded by tea which the very best cultivation and the most scientific pruning can never bring round."

Since the introduction of the "sau" as a shade tree several other leguminous trees have been tried and various species find favour in various districts, though generally speaking the "sau" is still the most popular tree.

In the following notes, all the available information likely to be of use to planters has been collected about each of the shade trees in common use to-day:—

Albizzia stipulata [Sau, Kala (or black) siris].

This is a fast growing tree with a broad flat crown and dark grey bark. The wood is soft, the outer sap wood being white and the heart wood brown. The name *stipulata* is derived from the fact that the young leaves have a pair of stipules or leaf-life projections at their bases. These stipules fall off later when the leaves become more mature. The complete leaf, as in many

other legumes, is compound, composed of 6 to 18 small leaves, and each of these leaves consists of 20 to 40 tiny leaflets about $\frac{1}{4}$ inch long. The leaflets are opposite each other on the stem, and there is no terminal leaflet. The flowers are yellowish, and the pods about 6 inches long and $\frac{3}{4}$ inch broad. The flowering period is from April to June.

There appear to be two fairly marked varieties of "sau", one in which the stipules and young leaves are green, and another in which they are reddish. The latter is slower growing, more upright in habit, and is generally considered the better of the two for tea.

When established along with young tea, the sau tree is easily grown on most tea soils and may last as long as 25 years without becoming cankered or diseased. The normal healthy life in manure tea is however not much more than 15 years, at which age the trees are easily liable to contract canker and disease. The mature sau tree is normally leafless from December to May.

Albizzia procera [Koroi, Safed (or white) siris] is a large tree of erect habit, with a whitish smooth bark. The heart wood is brown and much harder than that of the sau. The leaflets are much larger than those of the sau, being $\frac{3}{4}$ to 2 inches long, and are, as in the sau, in pairs opposite each other on the stem, with no terminal leaflet. There are 6 to 10 pairs of leaflets on each stem. The pods are 4 to 8 inches long and $\frac{1}{2}$ to 1 inch broad, containing 8 to 12 seeds. The flowering period is May to August and in many localities the tree is rarely leafless, though leaves are renewed in the rains. The tree is generally less liable to canker than the sau and has a longer life but suffers from attack by borers and red mites. The young plants are often attacked at the roots by larvæ of a Buprestid bug. In recent years severe attacks by a Cerambycid beetle have been reported.

Albizzia lebbek. This is a very similar tree to the koroi, but the bark is light grey in colour. It is a slower growing tree than the koroi and appears to suffer little from disease or pests. It is rarely leafless, flowers in April and May, and the seed is ripe in September or

October. This tree has not been very popular as shade tree, probably on account of its slower growth, but is well worthy of consideration in districts where koroi and sau are especially liable to disease and pests.

Albizzia odoratissima (Kakor siris). Similar to the koroi but smaller. The leaflets are also much smaller and more numerous than those of the koroi. It maintains considerable foliage in the cold weather and spring.

Albizzia moluccana (Ceylon sau). This is a very large and quick growing tree which maintains a heavy foliage throughout the year. It has a smooth light grey bark and the wood is soft. It has small leaflets similar to those of the ordinary sau. The pods are thin and flattish, 4 to 5 inches long and $\frac{1}{2}$ to $\frac{3}{4}$ inch broad and contain 12 to 16 seeds (800 to the ounce). The tree is a native of Malaya but is commonly used as a green manure tree in Ceyon. The soft wood makes it very liable to be broken in storms and in view of its huge size, damage to tea by falling branches is one of the chief objections to its use as a shade tree. Its shade is normally far too dense for tea, and with its evergreen foliage it is harmful to closely adjacent bushes in times of drought, though its shade should prove valuable on southern and western slopes of teelas, if the tree can be planted round the base of the teela.

In Ceylon the tree is lopped and the loppings used as green manure, but attempts to do this in North-East India are reported to result in the tree dying from wood-rotting fungi.

Other species of *Albizzia* include *A. myriophylla*, *A. lucida* (called Moj in Assam), *A. amara*, *A. mollis*, and *A. sumatrana*, the latter commonly used in Java and Sumatra.

Dalbergia Assamica (Bor medeloa) is a slow growing tree with a light grey bark. It grows to a large size and as it is little attacked by disease has a long useful life as a shade tree. It is very late in coming into leaf, and though its effect on tea is good it is not considered as useful as sau or koroi. Its leaves bear 11 to 17 large leaflets 1 to 2 inches long on each stem, and the leaflets

are alternate. The pods are $1\frac{1}{2}$ to 4 inches long and $\frac{1}{2}$ to $\frac{3}{4}$ inch broad containing 1 to 3 seeds. There are about 800 seeds to the ounce.

Derris robusta. This tree, generally known as the "derris", is a hardy tree, easily established on almost any soil. It is not liable to canker but its leaves are commonly eaten by a caterpillar (*Baradesa omissa*) apparently specific to this shade tree. The derris is generally not favoured as a shade tree, as tea is usually observed to be poorer under it than away from it, especially in localities liable to drought.

It maintains considerable foliage all the year round. The leaflets are 1 to $1\frac{1}{2}$ inches long, 7 to 19 on a stem, and the pods are 1 to 2 inches long, winged, and contain 1 to 5 very small seeds (1,500 to the ounce).

Cassia Siamea. This, like most cassias, is harmful to tea. Cassia species, though they are legumes, do not apparently fix nitrogen to any marked extent. The tree is medium in size and bushy in shape, and has heavy foliage even in the dry season.

Erythrina indica and *E. lithosperma.* Both of these trees are known as the dadap, and are much less used nowadays as shade trees than they were some years ago. Their effect on tea is considered beneficial, but their large heavy leaves falling on the tea have been reported to do harm by encouraging blights. Their roots, too, have been observed to be liable to brown stump rot which may spread to the surrounding tea.

The dadap is used commonly in Java and Ceylon, mainly as a source of green manure, by lopping frequently. Unless it is lopped rigorously up the sides its shade is too dense for tea. The bark of the *E. indica* is yellowish brown with a green tinge and the leaflets large (4 to 6 inches long). The *E. lithosperma* has a whitish bark with leaves similar to those of *E. indica*. Both species are thorny, but there are thornless varieties known. Both species have scarlet flowers, and twisted pods containing 1 to 6 seeds.

Other shade trees, seldom seen in North-East India, but common in Ceylon and Java are *Glyricidia maculeata*.

Leacaena glauca, acacia species and *Grevillea* robusta. The first three are leguminous and are lopped for green manure. The latter is non-leguminous and is generally used as a wind brake. It is decidedly harmful to tea in North-East India.

Whatever may be the relative merits of various types of leguminous shade trees, there is no doubt that better tea bushes can be maintained at less expense under moderate shade of sau, koroi and many of the other species mentioned above, than with no shade. It is true that excellent tea, giving upwards of 12 maunds per acre, can be seen growing without any shade trees, but the cost of manuring to maintain a high yield is considerably greater than if the tea had been shaded.

SHADE AND TEA QUALITY

In Upper Assam especially, the value of shade trees is a matter much debated among planters, and little experimental evidence is available to assist in arriving at a definite conclusion especially in regard to the effect of shade on quality. An experiment on single blocks of tea was carried out in the Bishnath district in Assam some years ago. The results of this experiment are given in the Indian Tea Association Pamphlet "The Nitrogen Supply to Tea" by H. R. Cooper, 1939, and are worth quoting here in full.

EXPERIMENT ON THE EFFECT OF SHADE ON CROP AND QUALITY

"The only recorded attempt at measurement of effect was made by Mr. Booker when Manager of Pabhoi. Three plots of 5 acres each, to all appearance very closely alike, were marked out in a section shaded by well grown sau trees (*Albizzia stipulata*) planted 30 feet × 30 feet.

At the end of 1922,

Plot 1 was left as it was.

Plot 2 was thinned out to keep sau trees 30 feet × 60 feet.

That is half the shade trees were removed.

Plot 3 was denuded of the shade trees.

This was young tea on good virgin soil to which no manure was ever applied.

The yields in maunds green leaf per 5 acres were :—

			1923	1924	1925
1.	Heavy shade	30 feet × 30 feet ...	224	231	209
2.	Moderate shade	30 feet × 60 feet ...	245	233	217
3.	No shade ...	... ...	233	195	158

In 1923 yields are not greatly different. Although the shade is removed, the nitrogen gained in previous years would still be effective. In 1924, tea crop falls greatly where the shade was removed, and becomes still worse in 1925. The trial then ceased.

We may assess the gain from the shade trees to be about $2\frac{1}{2}$ maunds dry tea per acre in 1925. This gain probably would have been increased in future years. The unmanured and unshaded tea would not maintain permanently its 1925 yield of about 7 maunds per acre. The shaded area would remain near its 1925 yield of about $9\frac{1}{2}$ maunds.

The moderate shade is roughly as effective as the heavier shade.

The Manager remarked that both the heavily and the moderately shaded plots showed excellent growth in 1925, but that tea leaves were darker under the heavier shade. This darkness might be due to deficiency of light. The unshaded plot looked yellow, and lacked vigour, and was full of twiggy and banjhi shoots. All three blocks were well cultivated so that the effect of the shade trees was not due, even in part, to suppression of undesirable jungle. It was due to increased nitrogen supply, and perhaps to the direct effect of protection from excessive sun.

Separate manufactures were made at monthly intervals during the three years.

Such single-plot experiments of course are liable to many sources of error. The 1925 reports, when effects would be likely to be greatest, are the most consistent.

During the rainy months, July, August, and September, 'no shade' led easily.

Tea from unshaded bushes was frequently reported on as 'light' or 'thin', but briskness, pungency, tip, and occasional flavour were more frequently reported from unshaded bushes. 'Moderate shade' was generally placed second, with 'heavy shade' third. In the autumn, however, and in the early season, the absence of 'colour and substance' in the unshaded tea caused 'moderate shade' to be placed first. Up to June, of course, there is little direct shade."

Generally speaking, one can say with some confidence that gardens of average quality will benefit from the use of sau or koroi shade planted not closer than about 50 feet apart. Denser shade is likely to cause loss in quality, and even loss in crop.

DISADVANTAGE OF THICK SHADE

There is no advantage, except perhaps a temporary one, extending over the first few years, in planting shade too thickly. One often sees young trees planted less than 30 feet apart, the intention being to thin out later when the trees have grown to such a size that the shade is becoming too heavy. Often, however, the thinning out is neglected and the result is that someone is faced with the expensive work of removing a large number of big trees, a job resulting in inevitable and extensive damage to the tea. The same state of affairs results when self-sown plants are allowed to grow unchecked. If however the shade is strictly limited to a spacing of not closer than say 35 feet when mature, there will not be more than about 35 trees per acre, a number which can easily be dealt with, when the time comes to replace them owing to age and disease.

METHOD OF PLANTING

Planting of seed at stake has been tried and occasionally found successful, but usually fails owing to the

choking of the young seedlings by weeds. It is essential to surround such young seedlings with a bamboo or wire protection and to see that the soil inside the protection is kept clean.

STUMP PLANTING

Stump planting has also been tried and found successful in some districts, but is generally not favoured as a method of establishing shade trees. Plants of any age up to 3 or 4 years, selected either from those self-sown in the tea, or from an adjoining forest, are cut to about 5 feet and lifted with as much soil round the root as is possible. Generally the tap root and many side roots are inevitably cut, and often the plant is "carrot planted", *i.e.*, put out with only a stump of a root. It is stated that the best time for stump planting is about February or early March, just before the new buds have burst. The chief objection to stump planting is that canker is likely to develop at the place where the tree has been cut.

PLANTING FROM A NURSERY

The most successful method is undoubtedly that of planting, at 6 months to one year old, from a nursery of shade tree plants. If the seed is put out in the early spring in a well prepared nursery, the plants should have made sufficient growth to be put out in the following cold weather. Nurseries can be prepared in exactly the same way as tea nurseries and if the seed has been put out early in the cold weather, high shade is desirable, as in the case of tea, until about the end of June when the rains break. With ample seed available the nursery may be sown in rows one foot apart and the seed 2 or 3 inches apart in the rows, to be thinned out to 8 inches or 1 foot later. It is a mistake to leave the seedlings too close as, apart from the fact that they cannot be lifted with good large balls of earth round the roots, their growth in the nursery is stunted by being too closely planted.

MANURE FOR SHADE TREES

Shade trees in general, like most other legumes, thrive better on soils of low acidity than on high acidity soils such as are so suitable for tea. If a shade tree nursery is not growing well, therefore, it is not desirable to apply sulphur (a treatment which is often beneficial on tea nurseries), as this only makes the soil more acid. Lime, basic phosphates, or calcium cyanamide, are alkaline manures which are most likely to prove suitable for shade trees. A good mixture for use on a poor shade nursery, or for applying to shade trees for a year or two after planting, is as follows:—

3 parts basic slag.
2 parts calcium cyanamide.
1 part sulphate of potash.

To a nursery this mixture may be applied at the rate of 1½ to 2 ounces per square yard and lightly forked in. To a plant the first year after it has been transplanted the manure should be applied in a ring about 2 feet wide not closer than 6 inches from the collar, at the rate of 4 oz. per plant. In the second year the application may be doubled, and the area of spread extended to a ring about 5 feet in radius, and not closer than 1 foot from the collar.

At the present time, owing to shortage of potash and phosphates, it is necessary to use cattle manure, composts, or the standard mixture, enriched with burnt bones and wood ash to provide the necessary phosphate and potash.

In planting out it is better to let the shade tree occupy the place of a tea bush, and not the space between four bushes. It is less likely to be damaged if it occupies the space of a tea bush, and it also has a larger area of soil in which to establish itself. It is therefore more likely to make good growth in early years than if planted between the rows of tea.

Cattle manure is a suitable manure for shade trees both in the nursery and when planted out, provided it is really well rotted. If not well rotted, it encourages insect

pests of various kinds such as the larvæ of the Buprestid bug which attack the roots of koroi; cockchafer grubs, etc., which may do harm to the young seedlings. It also encourages the growth of weeds and makes more difficult and expensive the task of keeping the young plants clean.

LOPPING OF SHADE TREES

Most types of shade trees require a certain amount of lopping in their early years, to remove the lower pendant branches and to decrease heavy shade. Many types of shade trees suffer from a wood-rotting disease after lopping, but the risk of disease can be reduced to a minimum by making all cuts clean and flush with the trunk or branch, and painting with bitumen (the same as that used for treating heavy pruning cuts on tea). A Dooars planter of considerable experience, who has adopted a system of regular lopping of koroi trees for many years with great success, considers that the right time for lopping is November and December.

WHITEWASHING OF SHADE TREES

Many gardens adopt a good practice of white-washing or spraying the stems of shade trees up to a height of about 8 feet. This is especially desirable on trees such as the koroi, the bark of which appears to be very liable to attack by mites and various other pests. The whitewashing or spraying should be done from the earliest period possible. In the nursery the plants may be sprayed with weak lime sulphur or a caustic wash, and after planting out, with a stronger solution, or painted with lime or caustic wash.

SEMI-PERMANENT GREEN CROPS

There are several plants of the leguminous type which are used in tea chiefly for their manurial effect, though their shade is also considered of additional benefit to young and heavy pruned tea. Of these plants

boga medeloa (*Tephrosia candida*), arhar (*Cajanus indicus*), *Crotalaria anagyroides* and to a lesser extent (practically confined to the Darjeeling district) Indigofera species (e.g., *Indigofera dosua*) are used in North-East India.

SHORT-TERM GREEN CROPS

At one time the use of a variety of quick growing green crops was common in tea, but of more recent years the use of these crops has been confined mainly to preparation of old tea land for nursery sites and for replanting. The plants which have been commonly used are the cowpea (*Vigna catiang*), mati kalai (*Phaseolus mungo*), daincha (*Sesbania aculeata*), and Bhotmas or soya bean (in Darjeeling).

Evidence shows that no benefit, but rather a depression in growth of tea occurs during the period that green crops are growing among the tea; and until a considerable amount of rotted vegetation from the green crop has accumulated in the soil, tea shows no benefit from the use of these crops.

The more luxuriant the growth of the green crop, the greater the depression in growth of tea until the green crop is uprooted and hoed in. Subsequently the tea benefits in proportion to the quantity of nitrogen available to the tea bush from the green stuff hoed in. In the case of crops such as cowpeas, experiments show that this subsequent gain in tea crop after hoeing in of the legume, just about equals the loss in crop resulting while the legume was growing, and the net result even after a period of years is no gain whatever to the tea.

Apparently such short term crops as cowpea merely put back into the soil what nitrogen they take out. In this connection it is interesting to note that it has been observed that certain leguminous plants, although their roots bear nodules, do not fix nitrogen to any extent until the plant is mature. Cowpea and such crops are usually hoed in, at or before the time they reach maturity.

In the case of boga medeloa or arhar, the depression in tea crop while the green manure plant is growing, is

considerably lessened by keeping the green crop rigorously lopped. By leaving the green crop unlopped, shade becomes far too thick for the tea bush which becomes "thin on top", and flushes poorly.

USE OF GREEN MANURES

It is now generally advised that green crops should be used only in young tea, cut back tea and tea which has not sufficient spread to cover the soil well. Furthermore, in general, green crops of the type of boga medeloa are the only ones likely to be of benefit to tea generally (with the exception that certain types of creeping leguminous plants might be used on slopes to prevent erosion).

LOPPING OF BOGA MEDELOA

Boga medeloa and arhar are best planted with the first spring rain in March or April, in thin lines in alternate rows of tea. The young plants will need some weeding, particularly during the early stages, to suppress deep rooting thatch grass, etc.

In the plains arhar lasts only one season, and should make enough growth to allow of two loppings before it is uprooted and hoed in, at the beginning of the cold weather. Boga medeloa lasts two, sometimes three years in the plains and can be lopped at least once during its first season. Generally it can be lopped up the sides about the end of August, but in any case should be lopped at the end of October. This is essential, especially in young tea and in droughty districts, as otherwise the heavy foliage removes too much moisture from the soil during the dry season. All side branches up to 4 or 5 feet should be cut off, and the top trimmed to leave merely a tuft of leaves and stems. In the second year three loppings of boga medeloa are possible, *i.e.*, end of May, August or September, and end of October. In May of the third year the plants should be uprooted, the leafy part cut off and retained on the area, and the heavy wood removed. A much greater total weight of green stuff is obtained by

regular lopping in the manner described above, than by leaving the medeloa unlopped, or only lightly lopped, and the chief value of such green crops lies of course in their manurial effect resulting from the readily decomposed vegetable matter they supply to the soil.

GREEN CROPS AND THEIR EFFECT ON PESTS AND BLIGHTS

In Darjeeling, the use of shade trees and green crops such as boga medeloa or Indigofera is commonly considered undesirable as they are thought to encourage blister blight, a disease which may reach serious proportions in the district. While it is generally agreed that on the higher elevations at any rate, shade trees are unnecessary and undesirable, boga medeloa if kept well lopped, should prove a valuable crop, not only for its manurial effect, but for its use in preventing soil wash. Arhar has also been used successfully on some Darjeeling gardens.

CHAPTER VIII

TEA SEED AND TEA NURSERIES

BOTANICAL CLASSIFICATION OF TEA

THE tea plant belongs to the genus *Camellia*, one of 14 genera comprising the order *Theaceae*. Originally tea was classified as *Thea* and named *Thea sinensis* in 1753 by Linnaeus, but was later not considered by botanists to differ sufficiently from *Camellia* in the particular botanical characters already considered to define plants of this latter genus. In 1935 a Conference of Botanists in Holland decided that the tea plant should be classed as a *Camellia* and a satisfactory name for the plant is *Camellia Sinensis* Link (Link being the name of a German naturalist to whom the scientific description of a preserved specimen of tea plant is due).

Plants belonging to other genera closely allied to *Camellia* are found growing wild in India. For example, the plant known in Bengal as *Chilouni* (*Schima Wallichi*) is common in North-East India, and is known in Assam as *Bher Gos*. Of the genus *Camellia* itself there are also species other than the tea plant growing in India. *Camellia drupifera* and other species grow wild in the Naga and Khasi Hills and are known to be actually used in making a kind of tea for local consumption among certain of the hill tribes.

At the present time there are many sources of supply of tea seed in North-East India, and the price varies from about Rs. 150/- to Rs. 250/- per maund according to the reputation which the particular brand of seed has in the industry.

HISTORY OF THE INTRODUCTION OF TEA INTO ASSAM

In order to appreciate the position in regard to tea-seed supply at the present time, an acquaintance with the history of how tea-growing started in Assam is necessary.

Very early in the nineteenth century it was found that wild tea was growing in Burma and in the hill districts to the east of Assam, and that the people of those districts were in the habit of using this plant for making "letpet" or pickled tea. In 1825, tea plants obtained from near Sibsagar were planted out by Mr. C. A. Bruce at Sadiya. Specimens of the leaves of these plants, together with those of some plants found at Manipur, were sent to Calcutta for identification and were both pronounced to be of the same genus *Camellia*, or *Thea*, but not the same species as the tea plant of China.

Twenty years later further specimens of plants from Assam were identified in Calcutta as being the same species as the China plant; and the Superintendent of the Botanical Gardens, Dr. N. Wallich, gave it as his opinion that it was waste of time to import the plant from China.

In 1835 Drs. Wallich and Griffith, botanists, and a geologist McClelland visited Assam to inquire into the possibility of successful tea culture. They found tea plants growing in many parts of Assam, both in the hills and in the plains; in the latter instance the probability is that the plants had been introduced and cultivated by the inhabitants, and were not indigenous.

Though Wallich favoured the use of the locally growing plants, Griffith advised importation of the China variety, and as a result much seed was imported from China and planted in various localities including Assam, South India, Dehra Dun, etc.

Since it was later found that the wild Assam plants could produce teas of marketable quality, both these and the China variety were planted out indiscriminately and the result has naturally been a hopeless confusion of varieties, since the tea plant is normally crosspollinated.

At the present time, therefore, it is not possible to buy a supply of tea seed of any guaranteed variety. It is common to talk of light leaf Assam, Manipuri, Burma or China *jats*, and to classify the product of a particular tea-seed concern accordingly, but such classification is necessarily very rough, and there is actually no valid distinction even between dark and light leaf *jats*.

It is generally considered that the light leaf Assam type of plant normally produces the best quality tea under plains conditions but is normally less hardy than the dark leaf type. Not all light leaf *jats* however produce the best quality, nor does it follow that because a plant has a dark leaf it will be a hardy one, and produce poor quality. For hill districts the China type is considered to be the best for flavour, but here again the fact of a plant having the external appearance popularly supposed to be characteristic of the China type does not ensure its success as a flavour producing bush. It will be impossible to make statements of a more definite nature than the above till selection and vegetative propagation work has proceeded further than it has at the present time.

The lines on which work of the Botanical Section of the Scientific Department of the Indian Tea Association is proceeding, are very briefly as follows :—

The leaf from individual mature bushes in sections of tea of various *jats* has been manufactured separately by a hand-manufacture system, and evaluated by a taster for quality, strength, etc., of liquors.

The variation between the quality and strength of liquors of teas made from individual bushes of the same *jat* is often very great indeed, as are also the variations in yielding capacity of individual bushes of the same *jat*.

The next operation is to mark off those bushes distinguished by some particular character of the liquors of the teas they produce, or by their yielding capacity, and to propagate plants from these selected bushes by some suitable method which will ensure that the "offspring" will retain the same characters as its parent bush. This is done by one or other of the various methods of vegetative propagation—cuttings, layers, grafts, etc., as distinct from allowing the bush to flower and fruit and collecting the seed, which, as the tea plant is normally cross-fertilized, might produce a large proportion of plants quite unlike the parents.

All the plants obtained from the same bush by cuttings, grafts, etc., form what is called "clone", and

each of the members of a clone carry the same characteristics as the original bush. Having accumulated a sufficiency of clonal material, the next obvious step would appear to be to plant out one clone in isolation, and to obtain seed from it which cannot have been crossed with some other, possibly undesirable, tea plant. Unfortunately this would involve self-pollination, which in the case of the tea plant results in a very poor seed crop in comparison with cross-pollination. Hence in order to obtain a satisfactory crop of seed it would be better to plant out the seed garden with two or more selected clones, so as to allow of cross-fertilization and a resulting good crop of seed. The result will be a mixture of the selected clones, and a fair percentage of the progeny may be disappointing, but the net result will be better in the particular characteristics aimed at than that from an indiscriminate mixture of seed trees such as is typical of most commercial seed gardens.

It must be remembered that plant breeding as practised in the case of annuals such as cereal crops, vegetables, and flowers, would take a very long time to produce definite results in the case of tea, where the length of a generation is several years, instead of one in the case of annuals.

The possibility of planting out cuttings, or making grafts from selected plants, to be used directly as plucking bushes is not to be forgotten, though it involves very high rate of success in grafting or in rooting of the cuttings. Actually there are areas of plucked tea in Java which consist of grafts from specially selected high yielding bushes, though these areas are of small extent. Vegetative propagation as applied to tea is now regarded as quite a satisfactory method of obtaining large supplies of tea plants required for plucking areas. This method of raising supplies of tea plants will come in time to be used commercially, and will certainly be used in improving existing seed gardens and in establishing new ones; but it is as yet only in its infancy as applied to tea, and much work of a technical nature remains to be done before

it can be of the great practical value it undoubtedly will prove to be.

The supplies of tea seed available at present are mainly obtained from commercial seed gardens either attached to tea estates, or run as separate concerns. Some seed, "Black Burma" for example, is collected in the hills to the east of the Surma Valley. The seed from any particular seed garden is known by the name of that garden, and is called a *jat*. By *jat* is not meant a type, strain, variety or any term having a definite technical meaning, but simply a collection of seed resulting from the particular collection of tea trees with which any particular seed garden is planted, or in the case of wild seed, growing in any particular locality which may or may not be closely defined.

SEED GARDENS

Most tea seed gardens in North-East India are put out in localities away from other tea, often in clearings in the jungle, to avoid the risk of unwanted cross-fertilization. The plants may originally have been selected according to the ideas of the man who put out the *bari*, on the basis of what he thought desirable and undesirable characteristics in the young plants. The distance of planting is usually 15 to 20 feet apart.

MANURING

Generally speaking cattle manure has most commonly been used, but of more recent years chemical mixtures have been tried and found to give satisfactory results. The manuring of seed trees is however more fully dealt with in the chapter on Manuring.

CULTIVATION AND DRAINAGE

Seed gardens require a considerable amount of cultivation in order to keep down grasses and weeds, especially in early years before the trees have produced a spread which helps to suppress jungle. It is essential

to eliminate thatch and other deep-rooting jungle. The roots of a mature seed tree spread over a large area of soil, and a thully or forking for two or three feet only from the collar of the mature tree is not sufficient cultivation to enable the tree to obtain its maximum nourishment from the soil. A mature tree should be cultivated so that a clean soil is maintained over an area at least equal to the spread of its foliage, and manures should be broadcast evenly over this area, except for a circle of about 2 feet radius round the collar.

PRUNING OF SEED TREES

In the absence of definite experimental results it is difficult to give any advice on the pruning of seed trees, except that it is obviously desirable to remove annually all dead or diseased wood, and to maintain the trees free from "rogamulla", *Loranthus spp*, the parasitic plant similar to mistletoe which is capable of killing a tree if allowed to grow unchecked. Any cuts on heavy wood which have to be made should be painted with bitumen paint. Except for the above reasons the pruning of seed trees is not generally recommended. Frequently one sees whole areas of seed gardens cut down, heavy pruned or even collar pruned because they are considered to be weakly infested with mosses and lichens and bearing poor crops, of seed. Often the real need of the trees so treated is manure, and cultivation to suppress weed growth; and in such cases the drastic pruning carried out does more harm than good.

TEA FLOWER AND SEED

The tea flower appears any time between July and October, and about a year elapses before the seed is ripe. It is carried in a thick capsule, sometimes bearing a single seed, sometimes three or four seeds together. (See the three illustrations opposite).

When the seed is ripe, the capsule assumes a dark green or a purple tinge, after which it begins to dry and

shrink, which causes it to burst, and the seeds fall to the ground. The seed is about the size of a boy's marble, the kernel being protected by a hard shell of dark brown colour.

PLUCKING SEED—FALLEN SEED

The greatest caution is necessary to ensure that the seed is fully ripe before being plucked; this is the more difficult, as the seed on a bush does not all ripen at the same time, and if the whole crop is wanted, a gang of pluckers must go round twice or three times, taking the seed as it becomes ripe. It may be plucked from the tree or gathered from the ground immediately after it has fallen. Seed which has lain on the ground for some time may not be very reliable—not that the soil injures it—but for the simple reason that the damp arising from the ground very soon induces germination, by which process the active life of the plant in embryo has begun, and the possibility of the germ being or remaining dormant has ceased. The plant must either be placed in circumstances where life can go on expanding or death is the result.

TREATMENT IN FACTORY

Immediately the seed has been brought into the factory in its rough state, it should be spread on the floor of a cool airy house or verandah, not more than three inches deep, and be kept overnight. In the morning it is to be sorted by hand, all refuse cleaned away, and all unopened capsules spread on a mat out of doors, so that the sun or wind may dry and crack the capsule. When this is done in a hot climate, care must be taken not to expose the seed too long, because the extreme heat of the sun is very liable to cause the kernel to dry up.

EMPTY SHELLS

There is always a proportion of the seeds, more or less large, which are mere empty shells without kernel.

Tea Flowers.

Leaves, Flowers, and Fruits of Tea.

These may be detected by placing some seed in a vessel of water, when the empties float very lightly.

Seed may be rapidly tested by being placed in a wire basket or sieve, and then dipped bodily into a trough of water. After skimming off the empties, which float lightly, the whole can be lifted out and dried again in the sun, before the water can have any damaging effect upon the keeping qualities of the seed.

It is important to note that tea seed may remain on the surface of the ground for several months without spoiling, provided that heavy rain does not fall and wet the ground sufficiently to induce germination. Seed has been gathered in January in perfect condition and has given satisfactory results, although similar seed, gathered in October and stored in a factory, lost its vitality in three or four weeks.

PACKING SEED

If the seed is to be carried to a distance, it should be packed as soon as possible after sorting. The materials used for packing are charcoal or soil, either sandy or clayey, containing a certain percentage of moisture. Dry charcoal or soil may induce the seed to dry out, while if conditions are too moist the seed may germinate or become mouldy. About 12 per cent moisture is generally considered satisfactory for charcoal or sandy soil and about 16 per cent for clay.

The seed must be packed in layers, with sheets of strong paper between, to keep the charcoal-dust or soil from getting to the bottom of the chest.

If the seed has to be taken a very long distance, or, for any reason, cannot be sown for some months, it must be packed in tin-lined cases and hermetically sealed. In this way it has been known to keep its vitality for several months.

For this purpose, it is necessary to see that the seed is cleaned and packed immediately it becomes ripe. Only seeds which sink heavily in the water may be used, all refuse sorted out.

Tea seed very soon loses its vitality, and should on no account be kept in stock for any length of time. If the nurseries are not ready for its reception, it may be kept in dry charcoal-dust or in sand, or it may be put into germinating beds, watered and tended in the usual way.

FERMENTATION OF SEED

In keeping tea seed, it is of the utmost importance to note that immediately after being gathered, it has a great tendency to ferment if kept in a close hot and damp condition. Let a large basket or a box be filled with fresh seed overnight, and in the morning the contents will have become so hot that the bare hand cannot be thrust into it. When this has taken place, the seed has fermented; it will look all right for a time, but the greater portion of it is dead, and the process of rotting is only a question of time.

This is undoubtedly a most fruitful source of disappointment regarding tea seed, and the matter is deserving of the most serious attention.

Until ready for packing or planting, the seed must be kept spread out, as before, to a depth of not more than three inches.

TESTING SEED

Testing seed to ascertain the percentage of good is not so simple as is generally supposed. To throw a handful into a pail of water is by no means a correct test, because if the seed has become a little dry, 80 per cent or more will float, although perfectly good, while any seed whose shells have been broken by rough usage will sink, as well as some other rotten and bad ones.

The ordinary way with careful planters is to count out a certain number of seeds, say, 100, and then crack them all, examining the kernels one by one; even this is not an accurate test, however, because the empties weigh very little, and as the seed is sold by weight, the only accurate method is to weigh the proportion of bad against that of good.

RULES FOR SOUNDNESS

With regard to the quality or condition of tea seed, some years ago a form of contract was agreed to by the Indian Tea Association, whereby it is assumed that seed should be at least 90 per cent good when packed at the garden in Assam; 75 per cent at Goalundo, and 70 per cent by the time it reaches Calcutta.

RAPID LOSS OF VITALITY

This shows how rapidly tea seed loses its vitality, and how important it is to get it into the ground as soon as possible. Germinating beds or nurseries should be ready for the seed before it comes to hand.

SEED AT STAKE

On many hill gardens, where there are good spring rains, a favourite method was formerly to plant out with germinated seed "at stake". The germinated seeds are taken very carefully out of the bed and placed in a small vessel containing some liquid manure, and each coolie takes his own lot to the land which has previously been prepared, lined and staked, with holes made at the stakes where the plants are to grow. In one of these holes the coolie carefully places one or more seeds in such a way that, when he fills up the hole with loose soil, the seed will be about two inches from the surface. He then puts a handful of grass over all to keep the sun from drying it up. Nowadays it is by far the most common practice to raise seedlings in nurseries, where they can get more care and attention during their early stages.

GERMINATION OF TEA SEED

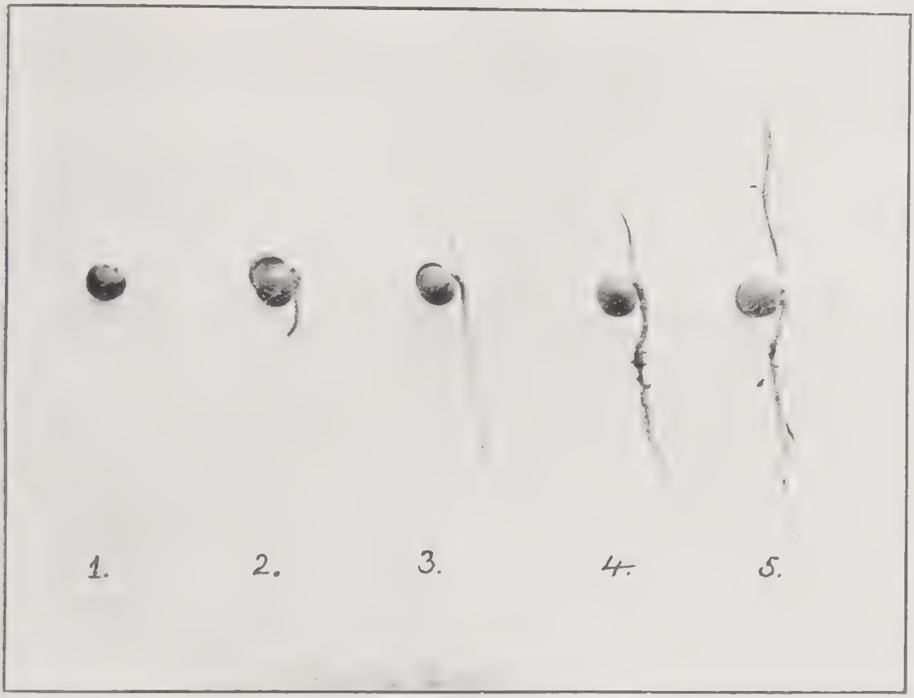
Tea seed is normally available for putting out in nurseries towards the end of October. When the seed arrives it should be taken from the boxes and put into

germinating beds, or put out in the nursery as soon as possible. Germination is done either in holes in the ground lined with straw or thatch, or in wooden boxes kept in a warm place. Layers of seed and clean moist sand or sandy soil are placed alternately, and the top covered with a layer of thatch to assist in keeping the germinating bed warm and in preventing drying out. Occasional watering is necessary to keep the sand moist. The seed is inspected at intervals and as the seed cracks it is removed and planted out in the nursery. Inspection should ideally be made daily, as if made at longer intervals some seed will have thrown out roots which are very liable to be bent, unless the seed happens by chance to be the right way up in the germinating bed. Moreover, in sorting over the seed when picking out the germinated ones, the tender rootlets are liable to be broken off.

Nowadays, with good reliable seed, germinating prior to planting out is generally omitted, but is still resorted to when poor seed, which is likely to contain a fair percentage of "non-starters", is being used. In planting out the seed whether germinated or not, it is advisable to plant it the right way up, that is, with the small round scar on the seed coat *downwards*. If seed is planted with scar at the side, or on top, there is every chance of getting twisted plants. In a light soil, seed planted not deeper than its own diameter will turn in the soil so that the root can go straight down, and there is little chance of getting twisted plants. In stiffer soils, especially if seed is planted too deep, the seed cannot turn and it is of particular importance in the case of nurseries on such soils, that the seed is planted the right way up, and not buried too deeply.

SELECTION OF NURSERY SITE.—NURSERIES ON VIRGIN JUNGLE SOIL

A good rich virgin soil is generally preferred as a nursery site, and plants normally do much better on such soils than on poorer ones, as for example, areas which have been in cultivation for a long period. The reason



Development of Germinated Seed.

is not so much the extra plant food in the virgin soil, for the young plant appears to feed mainly on its seed for at least the first year in the ground. The high organic matter in the virgin soil, rendering it in better tilth, is a very important factor. In growing any young plant from seed, that friable condition of the soil generally referred to as good tilth is of great importance, in that it encourages the young rootlets to extend. Moreover, the high content of humus renders a rich virgin soil more resistant to drought than a soil which has been long under cultivation. This is a most valuable asset in a nursery soil. Nurseries put out in a clearing in virgin jungle benefit from the surrounding shade and the protection from hot drying winds. The atmosphere is normally moister in such situations where there is continual transpiration from the leaves of adjacent vegetation. All these factors combine to make a nursery site on virgin jungle soil more favourable in general than an open area of uprooted or abandoned tea land. There are often however disadvantages,—damage by wild animals, for example, being not the least of them.

Often jungle land is not available, or is too far from the site of replanting or infilling; and a site possibly less favourable has to be chosen, *e.g.*, uprooted tea land, or grazing land.

NURSERIES ON POOR LAND

A soil of the sandy loam type is likely to give the best results. Clay soils are hard to maintain in good tilth and often suffer excessively from drought, while very sandy soils make the task of lifting the plant with an undamaged ball of soil round the roots, difficult. They also are liable to suffer more from drought than loams.

One important, and indeed essential soil factor, is a sufficiently high acidity. Plants do poorly on soils which are under-acid and it is well worth while having soils intended for nursery sites tested, before incurring an expense which may ultimately be wasted.

MANURING NURSERIES

The young plant appears to require no addition of nitrogen, potash, phosphoric acid or other mineral during its first year in the soil at any rate. Apparently it lives on the substance of its seed, for experiments show no results from manuring of nurseries, except when cattle manure is used. This manure is a valuable one for improving the friability of the stiff soil and in addition, as has previously been mentioned, is known to contain minute quantities of substances known as "auxiliary food factors", *auxins* and plant hormones which have a stimulating effect on root formation. Composts may be expected to contain these substances. They are present in the growing points, *e.g.*, the leaf buds of most plants, and are passed down to the roots. Mature plants thus make their own supply in ample quantity for their needs, but very young seedlings, having had no opportunity of making much growth, have to depend on what they can get from the soil for their *auxin* supply. A virgin jungle soil would naturally be expected to be rich in "auxillary food factors" from the decayed vegetation, but on poor soils, the supply needs to be augmented by addition of compost or cattle manure.

PREPARATION OF LAND FOR NURSERIES

If the nursery site is on a sandy or loamy soil with no pan, there is no advantage in deep cultivation. All that is required is a shallow hoe, 3 or 4 inches deep to level off the surface and to destroy weeds. It is often difficult enough to lift plants from a nursery on sandy soil with an unbroken clod of earth round the roots. Deep cultivation of such a soil only makes more difficult the task of lifting plants with clods intact. Stiffer soils often need a good deep hoe to break them up to a good depth, in order to allow the roots of the seedlings to penetrate easily, and there is no difficulty in taking unbroken clods from nurseries on clayey soils, which compact only too easily. Depth of hoeing is a matter

for practical experience depending on the type of nursery soil.

REMOVAL OF JUNGLE

It is essential to remove all kinds of jungle, particularly deep-rooting types, which are difficult to remove after the nursery has been planted. It is generally found best to put in a deep hoe, to a depth depending on the type of soil, in the spring, and at this time to take particular care to remove deep-rooting jungle, stumps, dead wood, etc. Then to leave the land fallow or under a green crop till the end of August, when a light hoe is put in and jungle or green crop buried. After this, until the nursery is planted out in October or November, the land is kept clean by scraping or weeding only.

DRAINAGE

It is usual in the plains to make nursery beds 6 feet to 8 feet wide, with drains about 1 foot wide and 1 foot to 18 inches deep between the beds. If the nursery is low lying it is advisable to surround it with a deep drain from which water is led away to the nearest convenient outfall.

DISTANCE APART FOR PLANTING SEED

In many nurseries the seed is planted up too close —5 inches and even 4 inches apart being not uncommon. This is intended as an economy in space but actually is a false economy unless the plants are to be put out at 6 months old, when 5 inches is a suitable distance. It is impossible to get good sound "bhetis" if the planting is too close, and in addition many side roots are cut. Instead of regarding close planting as an economy in the cost per acre of nursery, a sounder basis for calculation would be the cost per first class plant and it would

then be found that the wider planting was economically the sounder.

Experience shows that the following distances of triangular planting are suitable :—

For	6 month	plants	— 5	inches	apart.
,,	12 ,,	,,	— 8	,,	,,
,,	24 ,,	,,	— 10	,,	,,

Triangular planting is preferable to square planting as it does economize in nursery area. One can get 14 per cent more plants to the same area with triangular planting without the plants being any closer to their neighbours than they would be with square planting.

METHOD OF PLANTING SEED

The method of planting seed in a nursery is often a matter of individual preference, but one convenient system described in an article by H. R. Cooper (Indian Tea Association Quarterly Journal, 1924, p. 161) is worth recording in detail here.

"We usually make beds 7 feet broad. We then take 3 straight pieces of split bamboo about 9 feet long. On each piece two notches are made exactly eight feet apart. The three bamboos are tied together to form an equilateral triangle with sides 8 feet long. Two similar bamboos are then tied on to complete a diamond-shaped figure of which each side and the diagonal are 8 feet long (outside measurement). Two opposite sides are then marked by notches 8 inches apart. This figure is laid on the 7-foot bed which it covers leaving a fraction of an inch over. Another loose 8-foot bamboo with notches 8 inches apart, the first and last notches being 4 inches from each end, is then laid over the figure so as to join the first pair of opposite notches on the sides of the diamond. The notches on the loose bamboo indicate the places for the first 12 seeds, and so on. The sketch will make this clear.

If a bed of different breadth is preferred, the diamond-shaped figure should have sides equal to 1·155 times the breadth of the bed."

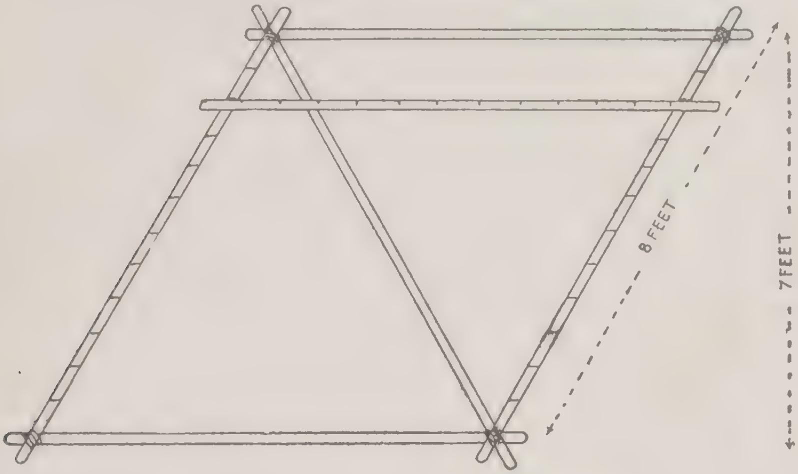


Fig. 7.—Frame for Planting Tea Seed.

As has been stated before, seed should be planted with the "eye" downwards, whether germinated or not, so as to ensure as many plants as possible with straight tap roots. There are of course other causes of bent tap roots, e.g., stones and other obstructions in the soil, and the use of seed which has partly dried out, leaving a space between kernel and outer shell. By planting out or germinating seed as soon as it arrives, much trouble from dried-out seed can be avoided.

DEPTH OF PLANTING

Under natural conditions in the jungle, seed falls on the surface of the soil and grows satisfactorily with nothing but a cover of fallen leaves, and the shade of surrounding plants. It is a great mistake to plant seed deeply. Half an inch of soil over the seed is ample. Seed planted much more than one inch deep often fails to come away at all. Dibbling in the seed with a stick is also an unsuitable method to employ for planting tea seed, partly because it is difficult to ensure that the seed is not planted

too deep, partly because the seed may fall the wrong way up when dropped into the hole, and partly because the stick polishes the sides of the hole and makes them less permeable.

One good method is to scrape the soil a little to one side, place the seed eye down, and replace the soil over the seed. Another very satisfactory but more expensive method is to place the seed in position on the surface of the bed and to cover it with fresh soil carried from the jungle. Such jungle soil, being rich in humus, is never so likely to pack and cake as poorer soil often does after wetting and drying.

SHADING OF NURSERIES

After planting the seed it is a good plan to cover the beds with a layer of thatch grass about one inch deep. This not only helps to conserve moisture in the soil, but protects the surface from being beaten down hard by rain. As soon as the plants begin to come through, the thatch should be lifted off the beds.

It is general nowadays, in districts which normally experience a dry cold weather, to provide overhead shade for nurseries.

REMOVAL OF SHADE

It is a common practice to build overhead shade consisting of thatch grass tied to bamboo frames. The shading should not however be too low, as plants are "drawn up" too rapidly. Moreover with low shade it is often necessary to remove it entirely about the end of June, as the plants are getting too high ; the sudden removal of shade at this time is liable to expose the plants to excessive sun which causes many deaths from sun scorch. High shade, about 5 feet from the ground, can be thinned out gradually, starting as soon as the plants appear to be becoming "drawn" by the shade, and at the time when the excessive sunshine of the early spring is mitigated by occasional showers. A certain

amount of thinning out of the shade occurs naturally, owing to winds. By about the end of September the shade is completely removed and by the time the plants are put out (in the case of 12-month planting), they should be sufficiently hardened not to wilt when exposed to the sun.

One objection often raised to high shade is that it is more liable to be blown down, with damage to the nursery, in storms and high winds. Care in erecting the supports and frame of the shade would of course do much to avoid damage from high winds. It is well worth while spending extra on making a sound job of the shading, and the extra cost cannot be more than a small fraction of the total cost of securing a good nursery.

GREEN CROPS AS SHADE

Shade is sometimes provided in the form of a green crop such as arhar or boga medeloa sown in lines between the beds. These crops grow much more rapidly than the tea plants and thus become of some use as shade, but their shade is of little use early in the year when the tea plants require it most. The green crops also take moisture from the soil when the tea plants may be badly in need of all the moisture they can get.

The best method of using a green crop for shading a nursery would be to establish it the year before in ridges about a foot wide between the beds intended for the tea seed, with a one-foot deep drain, 6 inches wide, on either side of the green crop ridge. The crop will then provide useful shade at the time when it is required, while its roots are prevented by the drains from spreading to the beds of tea plants. The green crop should be kept lopped up the sides and only a tuft of foliage left on top.

WATERING OF NURSERIES

Moisture is undoubtedly the chief factor contributing to the success of a nursery. With favourable rain in the cold weather and spring a good nursery is almost

a certainty, barring accidents and pests. Frequent showers in the cold weather not only maintain a moist soil, but reduce the periods of scorching sun.

Watering by hand is essential in the absence of showers but does not of course reduce the scorching effect of sun, nor does it help much in maintaining the moist atmosphere so favourable to the development of young plants.

If watering is necessary, a good soaking of the soil periodically is better than a continual light watering which merely damps the surface and dries off quickly.

PESTS IN NURSERIES

Nurseries are liable to a number of pests and fungus diseases which may, if unchecked, convert a potentially good nursery into a complete failure. Crickets are responsible for much damage to young plants, but much trouble from this source can be avoided by ensuring that any cattle manure or green crop applied is hoed in at least two, preferably three, months before the nursery is planted, and the soil kept clean by weeding or cheeling during this period. The cattle manure should be well rotted—fresh manure is likely to contain not only a large quantity of undesirable jungle seed, but also larvæ of pests such as cockchafers which eat the tender tea roots.

CRICKETS

Crickets in a nursery may be dealt with as follows. Boys are provided with tins of oil, e.g., dirty lubricating oil or a similar thick oil, and cans of water. When the cricket hole is located, the soil is brushed away from the entrance and a few drops only (about a thimbleful) of oil is poured in, followed by enough water to fill up the hole. The cricket tries to get to the surface for air and in doing so passes through the film of oil floating on the surface of the water. The oil fills up the breathing tubes and the cricket comes out and dies in a few minutes ; it is thus unnecessary to catch and kill the

cricket as in the case when water only is used, and there is no fear of damage to the tea plant from the use of so small a quantity of oil, even if the cricket hole is quite close to a plant.

Either D.D.T. or Gammexane in 5 per cent solution in crude kerosene are very effective if applied in a similar manner as above, in place of the oil.

EELWORM

Many nurseries are ruined by the attack of tea eelworm (*Heterodera marioni*), a common pest of tropical and subtropical crops. It attacks the roots of the young tea plants in the nursery, and usually the first sign of attack is late in the rains, when the leaves of the plants dry up and fall off, leaving a bare stem with perhaps one or two stunted leaves below the terminal bud.

If the affected plants are dug up, those attacked by eelworm have swollen places on the roots. Under a magnifying glass small holes may be seen on the swollen places, marking the places where the egg-laying females are situated. Previous to this stage the female as well as male eelworm are able to move freely about in the soil, and are tiny worms less than 1/25 inch long, almost too small to be easily visible to the naked eye.

No satisfactory treatment for eelworm infection in nurseries is known, though there are means of mitigating the pest. Shade reduces eelworm damage, and heating of the soil prior to planting the nursery also has good effect in many cases. Probably the best method of heating the soil is to burn a foot depth of thatch or other dry jungle on the soil just before preparing the beds for planting.

Soil disinfectants so far tried do not appear to produce any marked good result.

TEA APHIS

Young tea plants are very frequently infested with a black aphis (*Ceylonia theæcola*) which causes the leaves to curl up. Usually this pest does not appear to cause

serious harm and may be destroyed by spraying with weak lime sulphur solution, or nicotine spray.

RED SPIDER—LIME SULPHUR STRENGTH FOR NURSERIES

Red spider is also a common pest of nurseries, especially if unshaded, and should be dealt with by lime sulphur spraying. A suitable strength of lime sulphur solution for nurseries is one part of concentrate 30° to 32° Baumé) in 50 parts water, or if home made lime sulphur (about 9° Baumé) is used, one part in 10 parts water.

FUNGUS DISEASES ON NURSERIES

The fungus diseases which commonly attack nurseries are collar rot, which may be due to one or more of the following fungus diseases, *Hendersonia sacchari*, species of *Pythium* or species of *Rhizoctonia*, of which the first named is the most common. In addition, brown and grey blights, copper blight, and blister blight (more especially on the hill gardens.)

Spraying with lime sulphur or Perenox is effective as a prophylactic measure against these fungus diseases, and as a cure for the leaf blights. In the case of the collar rot diseases, the damage has been done by the time symptoms of the diseases become sufficiently marked to be obvious to the layman, and it is doubtful if spraying is of any use at this stage.

The burning of thatch or jungle on the soil prior to planting, and effective high shade, assist in reducing the liability to damage by collar rot. Perhaps the best spray fluids to use as a preventive measure are the 1 per cent Burgundy mixture with rosin adhesive, the formula of which is given in the chapter on Pests and Blights ; or ¼% Perenox. One spraying may be done before the rains and again about six weeks later. Subsequent spraying should be done with lime sulphur solution once a month.

It is not advisable to use the Perenox or Burgundy mixture more than twice on a nursery owing to the toxic effect of copper salts on the seedlings.

CHAPTER IX

SOIL EROSION AND LANDSLIPS

ALL tea areas, whether flat or sloping, are liable to loss of surface soil by erosion, just as are any other cultivated areas, flat or sloping, on which the natural close cover of vegetation is suppressed in favour of a crop growing less densely than the original flora.

Erosion is reduced to a minimum under tea bushes which are touching and completely cover the soil, and whose roots fully occupy the available soil ; these ideal conditions, however, are often least fulfilled on the areas which are most liable to suffer from erosion, e.g., the slopes of the Darjeeling district, and *teela* land in the Surma Valley.

CAUSES OF SOIL EROSION

Soil erosion may be caused either by the action of rain falling directly on to the soil, by the action of repidly moving water in streams and drains, or by the action of winds on dry soil.

Under the mild conditions which obtain in temperate climates such as that of Great Britain, for example, comparatively little loss occurs from soil erosion, and it is perhaps difficult for those who have no experience of tropical and subtropical conditions to realize the enormous havoc wrought by heavy storms on unprotected land. Figures for the loss of soil from this cause were given in an address to the Royal Society of Arts in 1938 by Dr. R. M. Gorrie of the Indian Forest Service. In the Kangra district in 1937, 18,500 lb. of soil per acre was carried away during a period of 32 days in the monsoon period. 3,511 lb., approximately $1\frac{1}{2}$ tons of soil per acre was lost as a result of a single storm of $5\frac{1}{4}$ inches of rain. This was on a slope of 1 in 4 of bare soil on which any grass growing was clipped every three days. Conditions

thus approximate very closely to unterraced hill-sides and *teela* slopes carrying poor tea or young plants.

As long ago as 1916, Dr. G. D. Hope of the Scientific Department of the Indian Tea Association proposed the following resolution at the 9th Meeting of the Board of Agriculture in India, at Pusa :—

"The Board suggests that the Government of India be asked to bring to the notice of planters, through the medium of the Indian Tea Association, the United Planter's Association of Southern India, district officers, and other convenient channels, the fact that the serious losses due to soil erosion in the planting districts which have taken place in the past, are to a large extent preventable ; that the most effective measures should be taken now on existing areas and when new areas are opened. The Board would suggest that the Local Governments should endeavour to safeguard against this danger of erosion when fixing the conditions on which new lands are given out."

Since that time much excellent work has been done on many tea estates in North-East India to minimize losses by soil erosion, but there is still much that could be done before it can be said that the Tea Industry has grappled successfully with the problem.

FACTORS INVOLVED IN SOIL EROSION BY WATER

Erosion by wind appears to be insignificant in tea districts, compared with that caused by water, in which the factors involved are :—

(1) Rainfall ; its quantity and rate of precipitation.
(2) The area and slope of the land.
(3) The nature and quantity of plant growth.
(4) The nature of the soil.

RAINFALL

In the tea districts of North-East India, rainfall conditions are particularly favourable to soil erosion.

The total annual rainfall varies between 60 and 250 inches, the average being somewhere in the neighbourhood of 100 to 120 inches.

SLOPE AND AREA OF LAND

Most of this falls over a period of 5 months, and it is during this period that individual storms of 4 to 12 inches occur. Generally speaking, land cannot possibly absorb all of the water which falls during such storms, and much must inevitably run off over the surface to be led away by drains. Where the land is reasonably level the removal without loss of soil, of excess water after heavy showers, is comparatively simple ; on slopes however the problem is much more difficult, and a combination of terracing, ridging, catch draining, etc., is necessary. If the area of sloping land is small, terraces or contour ridges may be all that is necessary but areas of large extent will probably require an elaborate system of drains.

PLANT GROWTH

The removal of natural plant growth—shrubs, trees and all forms of plants—which bind the soil together with their roots and protect the surface of the soil from the beating of rain by their foliage, naturally and inevitably leads to loss of valuable surface soil by erosion. Much has been written on the evil resulting from uncontrolled deforestation, and the following quotation from the Imperial Bureau of Soil Science Technical Communication No. 26, "Erosion and Soil Conservation" by G. V. Jacks and R. O. Whyte, is apposite :—

"Erosion caused by deforestation is severe in North Bengal and Assam. The outer hills of the Eastern Himalayas and the ranges south of the Brahmaputra were only a few years ago covered with dense forest. The rainfall varies from 70 to 200 inches, mostly falling between June and October. The *taungya* system of shifting cultivation (felling a hill-side, burning, cropping

for 2 to 3 years and leaving for 30 to 40 years) has been practised for centuries, and the long rest enabled the land to recover, as tree growth is rapid. Owing to disease and feuds, there was always sufficient land for the population without undue pressure on the forests. The result of British rule has been to increase the population and correspondingly to reduce the rest period. The consequent erosion has reduced stream flow, and shortage of water has forced the villagers to make new villages on hitherto virgin land. The main rivers in the plains are now frequently in a state of violent flood. In many parts of East India the extent of new shifting cultivation has to be seen to be believed; during the day there is a thick canopy of smoke over the whole country, while at night, looking up to the hills from the plains, the lights of fires can be seen as far as the eye can reach. Recent large immigrations from Nepal into Bhutan have resulted in the deforestation of a great area of the outer Himalayas with a monsoon rainfall up to 250 inches, and a very serious increase of floods in North Bengal. In many parts denudation by faulty cultivation and "jhuming" has been intensified by excessive grazing of buffaloes, cattle, goats and sheep, particularly in the Punjab and United Provinces. The worst results of torrent damage have occurred in the more fertile land at low elevations, where the destruction spreading from the banks of the rivers and streams has contributed to erosion.

Burma has suffered, but the vast area of forest still existing has prevented the damage from spreading widely. Here, and to a lesser extent in Bengal, Assam and the United Provinces, *taungya* has been adopted for afforestation purpose. The cultivators are made to sow or plant useful trees in rows between their crops, but they generally regard the trees as a nuisance and take little care of them unless constant supervision is exercised.

In the United Provinces, shifting cultivation has practically been stopped, but in Burma, Bengal and Assam little has been done to check it. The Darjeeling Hill-sides and Rivers Conservation Bill empowered the Deputy Commissioner to regulate the use of private lands

that were being denuded of forest, but it is not known to what extent these powers have been utilized. Elsewhere little or no anti-erosion legislation has been introduced."

Again, in Dr. R. M. Gorrie's address to the Royal Society of Arts (referred to previously), the following statement is made:—

"We can no longer consider forests in terms of jungle to be slashed away to make room for our more civilized activities or even as a mine to quarry timber and firewood. We have grasped that the forest is *par excellence* Nature's own best method of protecting and conserving soil and water supplies, and that where man has already destroyed the plant cover, steps must be taken to reduce the inevitable loss and desiccation to the slowest possible pace."

Soils which have been under "jungle" for a long period accumulate a litter of decomposed, partly decomposed and undecomposed vegetable matter, the value of which lies more in the fact that it improves the permeability of the underlying soil, rather than in its capacity of absorbing water. The combined effect of this forest litter, and that of the stems and leaves of the plants growing on the soil, is to reduce rapid run off of water, and to increase the amount which percolates through the soil.

On grass land the run off is likely to be greater than that on forest land; while on grazed land, percolation is least and run off greatest. Cultivated land is often very impervious to rainfall as, although the top few inches of soil may be loose and permeable, a very impervious layer of soil may be formed just below the normal depth of cultivation. On cultivated areas, with no surface litter and a spaced plant growth, surface wash may be very great indeed.

TYPE OF SOIL

The type of soil is an important factor in soil erosion. The clay fraction of a soil, perhaps its most important constituent, consists of particles so small that they

are easily carried away in suspension, even by the most gently flowing stream of water. In a clayey soil in good condition (tilth) the fine clay particles are cemented together in aggregates which are more difficult to carry away in suspension in water and are quicker to settle out from suspension, than the individual clay particles, Soil treatment which improves the tilth of the soil therefore assists in reducing erosion of the valuable clay fraction of a soil.

Furthermore, the stiffer soils in poor tilth do not allow as rapid percolation as do those in good tilth. Thus a soil in poor tilth becomes more readily saturated in the top layer; friction between particles is decreased, and the soil slips away more readily under heavy rain.

Very sandy and stony soils are less liable to surface erosion than stiffer and less stony ones, though on the former type of soil, the maintenance of drains, ridges and terraces is more difficult. Unless these are kept in a good state of repair, soil erosion is likely to be as great if not greater than on the stiffer soils.

PREVENTION OF SOIL EROSION ON TEA AREAS

By employing the correct, and frequently not the most expensive methods of cultivation, drainage, manuring, green cropping, plucking and pruning, soil erosion on both flat and sloping tea areas can be reduced to a minimum.

CULTIVATION METHODS

On all but the most gradual slopes, contour terracing is to be recommended as being the most effective method of reducing soil wash to a minimum. This subject is referred to in the chapter on Cultivation. It is frequently a matter of great difficulty to terrace slopes which have been originally planted up unterraced, especially when the planting is up and down the slope instead of round contours. It will be found that a compromise is required, unless the area is entirely replanted :

small individual terraces holding only a few bushes, in some cases only one bush, may have to be made, with little or no regard for exact contours.

On land of more gradual slope, contour ridges may be all that is necessary. These can often be established by planting out a green crop such as boga medeloa in contour lines and leaving it for 2 years or more. It will be found that the stems and roots of the green crop together with the weeds growing near to it form a check to the wash of soil, and a ridge is developed which remains after the green crop has been cut down. This ridge should not be hoed but should be sickled at intervals and maintained as a permanent barrier to further soil wash. In the Darjeeling district the use of a green crop such as boga medeloa is often feared on account of its shade which is considered to encourage blister blight. If however the green crop is kept rigorously lopped up the sides for about 5 feet, and across the top at about 6 feet, the shade is not likely to be sufficient to encourage blister blight.

FALLING IN OF DRAINSIDES

Much loss of soil often occurs even in the plains owing to drainsides falling in and the soil so disturbed being washed away down the drain. One frequently sees drains which originally had vertical sides, converted into broad V-shaped gullies, due to the fact that the soil was hoed right up to the edge of the drain.

On the loose bheel soils of the Surma Valley, the drains often occupy as much as one-third of the area of a section, when originally they occupied certainly not more than about $\frac{1}{10}$th of the area! It is sufficient to leave an uncultivated strip of about 6 inches wide on the edge of each drain, sickled when necessary. Another useful method of preserving drainsides especially on sandy or sloping land, is to make a small "bund" of soil a few inches high along all drainsides. Grass is allowed to grow on these bunds, and is sickled as necessary.

Drains on sloping land should always have "bunds" on the upper sides to prevent any rapid rush of water down the slope and over the drain edge.

Care must be taken in regulating the rate of flow of water through drains especially on slopes. Where the soil is very pervious and the subsoil stony, outlets to drains are often unnecessary as the function of the drain is in this case merely to allow surface water to pass quickly into the subsoil. Where outlets are necessary they may be led into "jhoras", natural streams running down the slope. If much natural outlets are not available, then a system of "staggered" drains is necessary to allow of a controlled passage of water to the nearest natural outlet.

CULTIVATION ON SLOPES

The first principle of slope cultivation is that the individual shall work upwards, i.e., with his back to the slope, if hoeing. In this way the soil is pulled up the slope, to counteract the natural downward movement of soil due to erosion. Where bunds, terraces and drains are damaged and need to be repaired, this should always be done with soil from below, and not from above the site. Where the slope is well terraced, cultivation to suppress weed growth on the flat part of the terraces may be done without risk of the loosened soil being washed away, provided a strip along the edge of the terrace is left unhoed to be sickled when necessary. The sloping faces of the terraces should of course never be hoed, but sickled only. One often sees terraces with bushes right on the edges, their roots often sticking out of the terrace face. The bushes were obviously not planted like this, and the state of affairs has been brought about by continual cheeling and scraping of the terrace faces, to remove weed growth. However carefully this scraping is done, some soil is inevitably removed. It is therefore much better to confine operations on the edges and faces of terraces to sickling only.

COVERING THE SOIL TO PREVENT EROSION

By encouraging the tea bushes to spread and touch each other a very effective protection against the erosive action of heavy rain is obtained. Spread of bushes can be obtained by a combination of adequate manuring; flat pruning and plucking, taking particular care to leave all side branches; and a system of cultivation which aims primarily at suppressing weed growth with as little disturbance of the tea roots, as possible. On sloping land excellent cover has been obtained by pruning and plucking bushes parallel to the slope, instead of on a horizontal plane. This means that the bushes have longer growth on their upper sides than on the sides lower down the slope. Actually plucking and pruning of such slope pruned bushes is easier once the sloping surface has been established, but what is most important is that the spread of the bushes gives far more effective protection to the soil beneath.

MULCHING WITH WASTE VEGETABLE MATTER

The application to the soil without hoeing, of waste vegetable matter collected from adjacent jungle areas, etc., has long been practised by many hill gardens, as a means of protecting the soil from erosion. Old thatch, jungle leaves and forest litter, leafy portions of shrubs and other plants cut from jungle edges and in fact practically any available waste vegetable residue is useful for this purpose. It is laid on the surface of the soil between the bushes and left to rot on the surface. Apart from minimizing soil wash, the cover of such material reduces very greatly the growth of weeds and undoubtedly has good effect in improving the tilth and porosity of the soil underneath. There is of course a very considerable manuring effect derived from such waste vegetable matter. An application of such material at the rate of 10 tons per acre may have as much manurial effect as 200 lb. of sulphate of ammonia.

To avoid risk of fire in the dry season, the mulching may be done in strips, applying in strips of two or three

bushes (or terraces) wide and leaving alternate strips of bare soil to act as "fire lines".

LEGUMINOUS COVER CROPS

Erosion of sloping areas of tea is greatly minimized by allowing a cover of weeds to grow up between the tea bushes, but it is obvious that the tea will suffer, not only from competition with such weeds for the plant food in the soil, but chiefly because the presence of these weeds greatly reduces the rate of formation in the soil of soluble plant food, *i.e.*, nitrates.

Weeds vary however in their harmful effect, those of a leguminous type being in general less harmful than the non-leguminous types.

In Java a study of the most suitable types of leguminous plants has been made with the object of selecting the best for use as ground cover crops in tea areas. Reference to the various types of suitable leguminous crops is made in the chapter on "Green Manuring and Shade Trees". Much more use might be made of these green manures as cover crops on steep slopes to reduce erosion, than has hitherto been the case in North-East India.

One very valuable means of improving poor eroded tea land is top dressing with new soil. This is a matter which in the past has been very greatly overlooked, and even at the present time there are very few persons who realize its value.

IMPROVING POOR LAND BY TOP DRESSING

The great problem for many tea gardens, especially in hilly country, is how to improve worn-out land, or to replace soil which has been actually carried away. There are many gardens which have patches of naturally poor land between blocks of good tea, and it is not desirable to sever the connection by abandoning the poor patches. In all such cases, it is possible to transform the poor land into rich fields if there is jungle within reasonable distance from which surface soil can be extracted.

It is always advisable to have the soil which is to be used for top dressing analysed to see whether it is sufficiently rich to be worth while carting and applying. Some soils which look rich often turn out to be no better than the land to which they are applied.

DEPTH AND COST PER ACRE

The depth to which top dressing may be done with advantage on badly eroded slopes varies with circumstances, and where there has been great wash, perhaps as much as a foot deep or more will be required. Under ordinary circumstances, it is necessary to dress to a depth of three to six inches; this, when it settles down, will become something like two to four inches all over, and experience has proved that such a dressing has an immediate and permanent good result upon the tea. A covering of six inches deep all over means something like 650 tons to the acre, and of course represents a great deal of labour, but if the work is done over a period of years and the soil not very distant, it can sometimes be done for Rs. 60 to 80 per acre. Hill gardens are usually much cut up by ravines, and pieces of very steep or stony land which are unsuitable for planting can yet be made to yield enough soil for this purpose. On some estates a good deal is saved under this heading by the use of wire tramways, but on almost all estates there is some time of the year when labour is in excess of the requirements, especially in the dry weather after cultivation has been completed and leaf is scarce. It is at this time that a very large staff of coolies may be employed at this work, and infinitely better employed than in merely stirring up ground which is already in a high state of cultivation.

COMBINATION TOP DRESSING

In some places it may be that there is abundance of green scrub to be had, but very little soil of any value; in these circumstances a combination of green manuring and top dressing may be found most advantageous.

First the scrub and grass, etc., in the jungle is sickled and then carried together with all dead leaves and decaying vegetable matter which can be swept up; this is spread on the ground under the tea bushes. A separate gang of coolies then carries enough soil to cover the whole. By this system a little soil goes a long way, and the green stuff, besides protecting the ground from drought for the time, becomes itself a valuable manure, especially for stiff soils.

LANDSLIPS

The following pages deal with the more "spectacular" aspect of erosion, when large portions of the land on steep slopes are detached and carried away after heavy or prolonged periods of rainfall.

EROSION OF MOUNTAINS

The natural condition of all mountains is one of more or less gradual erosion and diminution; portions or particles are continually being carried by the action of the elements down to the plains below, or away into the depths of the sea. The steepest portions of the mountain sides suffer most, both from the ordinary and somewhat slow action of wind, rain, frost, heat, and snow and from the sudden devastation wrought by earthquake or by cloud-burst, when it may be said that the mountains literally flow down.

ACTION OF NATURAL FORCES—SPACE LEFT BY MOISTURE

The ground is being constantly subjected to various influences which have a mechanical effect upon it, and prepare it for the direct action of water which eventually carries it off piece by piece. At the altitudes where tea gardens can be planted, very little frost or snow may be expected, but the ground is subjected in some measure to the influence of heat and cold which cause rocks, etc., to expand and contract alternately, and so tend to

separate them : the air at the same time acts upon certain portions of rocks and stones, causing them to decay and become disintegrated, so that separation is easy. By far the most effective of the forces at work, however, are the changes of season from wet to drought, when the influence of a tropical sun penetrates to a great depth and extracts the moisture from both soil and rock; the immediate effect of which is a somewhat uneven shrinkage in bulk and a consequent loosening of the whole fabric. Sometimes great cracks or fissures are by this means formed in the ground, but more usually the whole becomes permeated by a network of tiny fissures which communicate with one another, but which may not be readily noticeable. Soil of a stiff or clayey nature shows these cracks very readily, because they are always larger owing to its tenacious nature which prevents it being split up into small divisions. In every case the result is the same; however, when moisture has been carried off, an amount of space must be left behind, corresponding exactly to the volume of water displaced. The ground thus loses a good deal of its cohesiveness and becomes year by year more ready for the levelling forces of rain and flood.

EFFECTS OF RAINS—SATURATION

With the onslaught of each succeeding rainy season more or less of the land gets carried away to lower levels, or into streams and rivers; at the same time a great deal of water percolates into all the fissures caused by previous drought and softens all that is soluble, making it ready for any force which may be sufficient to detach any portion of it from the rest. When there is an excessive and continuous fall of rain, some portions of land which have previously become loosened get so saturated and soft that the whole thing is practically in a fluid state, and with the enormous added weight of water great portions commence flowing away to a lower level, carrying devastation and destruction in their course, and leaving a great scar on the mountain side.

DARJEELING DISASTER

It is not often that any very large area is involved in one landslip; only the looser portions of the land give way first, and the usual result of a specially severe deluge of rain is that the mountain side is more or less scored here and there by small landslips all over the steeper slopes. Sometimes, as in the case of the Darjeeling Disaster of 1899, there have been fully five hundred distinct landslips on as many acres of cultivation, and involving a loss or destruction of something like seven per cent. of the cultivated area.

When land has been cleared for cultivation, the natural condition of things is of course altered; the process of disintegration is somewhat accelerated, and the liability to slips is increased. The removal of forest trees or shrubs has a very direct effect in this way, as the land is no longer held together by their roots, and the latter, on rotting, leave channels in the ground for the inflow and dissemination of water.

WEIGHT OF WATER PER ACRE

Of the ultimate or immediate causes of landslips, the actual deadweight of water is the most important. As already stated, there is an enormous weight of water annually dashed upon the surface of the ground in the form of rain. Every inch of rain means a fall of 101 tons of water upon each acre of ground, so that in places where the annual rainfall is a hundred inches, each acre gets a weight of 10,100 tons during the season. It is thus at once seen that during a spell of unusually heavy rain, there is a very serious weight added to the soil, and a consequent impetus is given to any portion of land which may be ready to slip. It has been reported that during the time of the Darjeeling Disaster in 1899, something like 28 inches of rain fell within about forty hours, which means that during that short time each acre of ground had to bear a superimposed weight of fully 2,800 tons of water. It is not wonderful, therefore, that great portions of the hill-sides at the steepest places were

carried away, and that the floods brought devastation also to the valleys below.

SURFACE DRAINAGE—MAIN DRAINS

Surface drainage has naturally an important place in any efforts to protect the hill-sides from wash or from slips, and yet the most common cause of small landslips is not so much want of such drainage, as drainage misdirected. When drains are constructed at all, they should be made to cope effectively with a good deal more than the ordinary flow of water; they should be capacious enough to carry off easily the largest flood which has ever fallen upon the land. The runs should be short, and the openings into streams or masonry drains as frequent as possible. All main drains and all drains with a steep gradient should be of masonry with ample capacity. The openings or debouchings of drains are of the greatest importance; sometimes they are made to deliver their water simply upon a piece of somewhat level land, which, in ordinary times, answers very well, but when a long spell of very wet weather takes place, this land gets exceedingly overloaded with water and the water soaking through the ground bursts out unexpectedly at some point lower down, thus causing a landslip. Sometimes the simple rush of water at the outlet of a drain cuts into the soil in such a way as to undermine the land around it, gradually gathering force and impetus, until in the course of a few hours the rut which has been formed presents all the features of a scar resulting from a sudden landslip.

NATURAL CAVITIES

Occasionally a landslip takes place in the midst of a patch of tea where the land is fairly level, and at a place where such a thing is least expected; no drains being anywhere near and no cause whatever apparent. In such cases the slip is usually caused by a natural cavity in the hill-side, which has become filled with

water soaking down from above and so becomes an underground reservoir; the gradual decay of rock, or the operation of other forces described above, eventually makes a small opening communicating with the cavity, through which the pent-up volume bursts, tearing away everything in its course until the reservoir is thus drained away.

EXCESS WATER

However desirable it may be that the soil of a tea garden should get all the benefit possible from the manurial properties of rain water passing through it, it is of much more importance that the soil itself should be retained, and so both surface wash and landslips must be guarded against by ample and efficient surface drainage, giving every facility for all excess water being got rid of as rapidly as possible.

PROMINENT TERRACES

In making a new garden which requires to be terraced, or in terracing an old piece of tea, terraces should never be made too prominent, for several reasons: if very prominent they are then too easily broken down; they are exposed very much to sun and wind, and hence in dry seasons the bushes will suffer severely from drought; but the most important reason is that of they stand out perfectly level, they hold too much water during excessively heavy rain; the immense weight of the sodden soil makes them sometimes bend forward and crack at the back; there is then a rush of water into the subsoil, and down some fissure amongst the loose rubble between the soilcap and the bedrock, the consequence being a landslip, more or less serious.

REPEAIRING DAMAGE

The measures to be taken to repair damage by landslips are of two classes: the recovery or replanting

of lost or damaged areas, and the proper dealing with hopeless slips so as to prevent their increasing in area or undermining other portions of land.

RESUSCITATING BUSHES

When a patch of tea has been simply overwhelmed or obliterated by a slip from a hill above, it may be possible to recover a great portion of it by carrying off the excess soil for use as top dressing to poor ridges in the neighbourhood. After the Darjeeling Disaster, a considerable area of tea was recovered in this way, and in some instances bushes were resuscitated after having been buried under a depth of several feet of earth and stones for four months; they were then very heavily pruned, and the growth came away splendidly, the bushes being in a few months as good as ever.

CRACKS

Sometimes cracks or fissures appear as a result of a plot of land partially slipping or settling down. All such cracks should be filled up and rammed as tightly as possible; if left alone, they will form channels for the inflow of water to the subsoil, and the land is almost certain to slide away during the next heavy burst of rain.

REPLANTING

If the accumulated soil is too deep for carrying away, it may be dug over like new land, cleared of stones, etc., and replanted. The soil at the new surface may look very poor, being partly subsoil from the hill above, but there is a double depth of good soil underneath, and in course of time the new patch of tea will be better than anything in its neighbourhood.

On slips from which the surface soil has been carried away, and only subsoil left, the advisability of replanting is very doubtful, but if there is still remaining some admixture of surface soil as well as some good subsoil,

the replanting may be done with advantage, more in order to keep the plot of tea complete than for any profit likely to accrue from such cultivation. If the future yield will be sufficient to pay for their upkeep, it is better to have such patches under tea ; because little patches of jungle here and there amongst the cultivation are a great source of trouble and loss in measuring up tasks, and in that the jungle seed from these patches gets blown into the tea all around and continually generates troublesome weeds.

SCARS

No attempt should be made to replant with tea any deep scars from which all soil of a productive nature has gone. Any attempt of the sort can only result in complete failure.

PLANTING FOREST TREES

There are certain kinds of forest trees and shrubs, however, which thrive upon such situations, and may be planted with success, such as the Uttis, the Saur, etc. All coniferous trees, such as cryptomerias, pines, etc., are fond of sandy soil and can be made to grow on scars left by landslips. Bamboos also grow well and bind the soil splendidly. Before planting these places, the unevenness of the ground should first be smoothed a little, and the seeds or plants put at proper intervals, the spaces between being planted with shrubs, such as totni, sisnu, etc. Any kind of grass that will grow, should be encouraged.

PROTECTIVE WORKS

Sometimes it will be found that at the head of a scar the hollow is so deep as to undermine a piece more of the land above it, which thus becomes in danger of slipping at some future time. It is, therefore, advisable to build a stone revetment at these places, both in order

to prevent another slip, and to protect the tea immediately above from exposure to drought. This can, however, only be done if there is an ample supply of stone near at hand; otherwise the benefit would not be worth the expense.

GORGES—DEEP DRAINS

Excessive rainfall, accompanied by landslips and local floods from water which has been temporarily dammed up, occasionally alters entirely the character of the bed of a drain, so that what was before a tiny rivulet on the surface of the ground is now a deep gorge with very steep sides, the water cutting deeper and deeper and the sides continually falling in, resulting in ever-widening damage. If in such instances the stream has found the bed rock the area of loss cannot greatly increase, but if only still flowing upon loose stones and sandy soil, it is sure to increase further, unless measures are taken to make an artificial bottom. This can be done by building roughly with large stone slabs, if they can be had; these should be made in the form of steps, with side walls to keep the banks from falling in. This work also must be restricted to the amount possible to be done in the circumstances, and the expenditure of labour upon it will be justified only if the property to be protected is worth so much. When buildings are in danger from a condition of things such as this, the expenditure will probably be amply justified and, after all, it is wonderful how cheaply and efficiently such work can be done by ordinary coolies, with a little careful training.

WOODEN TROUGHS

Wherever stones are not available for this work, a wooden trough may be made for the bottom of the drain at comparatively small expense, and will probably last until the ground becomes consolidated and till the steep banks can be covered with a growth of trees, shrubs and bamboos, etc., to bind the loose soil together.

CHAPTER X

ROADS

FOR gardens in level well-drained country, the construction of roads is comparatively easy. Garden paths are usually about 12 feet wide, including if necessary a drain at one or both sides, the soil excavated from the drain being used for raising the road.

Main roads require to be 20 feet wide or more to allow of cart traffic and to allow two carts or other vehicles to pass. The tendency generally now is to have wide roads traversing most parts of the estate, so that managers may get about freely by driving, or motoring, which is so much less exhausting than saddle work. Work such as manuring, infilling, etc., can be much more efficiently carried out and supervised on a garden with plenty of good roads and paths.

CULVERTS

In connection with the drainage system of the garden, culverts or bridges may be necessary at intervals and must be provided at all crossings. It is necessary to have these either of stone or brick, or merely bridged with very substantial hard timber. Although on many estates bamboo bridges are still the general, rule, reinforced concrete or nested steel culverts are becoming popular. Many a fine horse has been ruined, and many a planter's collar-bone broken by the horse putting his foot through a rotten culvert or bridge. In a matter like this the old saying: "A stitch in time saves nine" is peculiarly applicable, especially if some of the ultimate stitching has to be done by the surgeon.

REINFORCED CONCRETE CULVERTS

Culverts of reinforced concrete are easily made on any tea garden and taking into account their durability

Making Reinforced Concrete Culverts.

are probably the cheapest means of taking drains under roads. The reinforcement may consist of hoop iron or iron strip, while the cement concrete mixture which has been found suitable for this work is made up of :—

3	parts	stone chips ($\frac{1}{2}''$ to $1''$ size).
2	,,	sand.
1	part	cement.

The culverts are made in sections 2 feet or so in length and the diameter may vary according to requirement from 18 inches up to 3 feet, with a thickness 2 to 4 inches according to diameter.

When the land alongside the road is a bit stony, the line of road may be trenched to the depth of a foot or so and the stones gathered from the cultivation buried there with a layer of earth or better still gravel on the top. This has been found by experience an excellent plan, and results in a splendid permanent road.

The stones can be buried in trenches on the two sides of the road, where wheel traffic may be expected to operate.

MARSHY GROUND

In carrying roads through marshy land, much difficulty has sometimes been experienced. Raising by earthing up is sometimes not sufficient, as the soil itself is of such a boggy nature, that no kind of treatment seems to render it solid in the rainy season. The most common way of dealing with such places is to use branches of trees laid across the road, or logs of wood, touching and continuous, covered with some light brushwood and soil. A very simple plan is to use elephant grass, or even sun grass, laid across in the same way, and the result is a wonderfully firm road, with none of the roughness of the corduroy road, by which name the log system is known. The grass lasts much longer than one would think, because the very marshiness of the ground prevents it from rotting soon. The preserving qualities

of mud are well known to the Bengali cultivators, who purposely steep their bamboos in muddy water for weeks or months before using them for buildings, which treatment causes them to last much longer.

HILL ROADS

The making of roads for a hill garden is much more difficult, and requires in some instances a great deal of skill and attention.

GRADIENT

Main roads may be 10 or 12 feet wide, exclusive of drain, but ordinary garden paths from 4 to 8 feet only. A good useful gradient is about ten degrees, or 1 in 6, and unimportant short cuts may be made as steep as 1 in 4.

CLINOMETER

The "Self-registering Clinometer" enables any planter to survey and arrange the alignment for new roads of any gradient without difficulty. Even before the jungle is cut, it is possible to mark out the alignment accurately by the use of this instrument.

SHORT CUTS

It should be borne in mind that the easier the gradient up-hill, the longer the road, to a given point above, and if the road seems too long, coolies will not use it, but will make a short cut. In important places it is advisable to build a permanent short cut of stone steps straight up-hill, because no man on earth can stop coolies from making short cuts, when there is a great deal of traffic, and for this reason it is better to build a permanent one, which will not soon wear into a deep water-course, and carry away great quantities of soil from the cultivation.

SLOPE OF HILL ROADS--DRAINS

The question as to whether roads should slope outwards or inwards has been much discussed, and a combination of the two systems is found to work best. It is beside the question to argue that the water should be allowed to find its natural course, because when any one begins to make a road, he alters the natural state of things, and he further makes a very important alteration when he cultivates the land both above and below the road. Wherever a road winds downwards, from a hollow towards a spur, it may be made sloping outwards, because in such circumstances any water going from the road has a tendency to spread, owing to the round of the hill, rather than to concentrate. When a road has

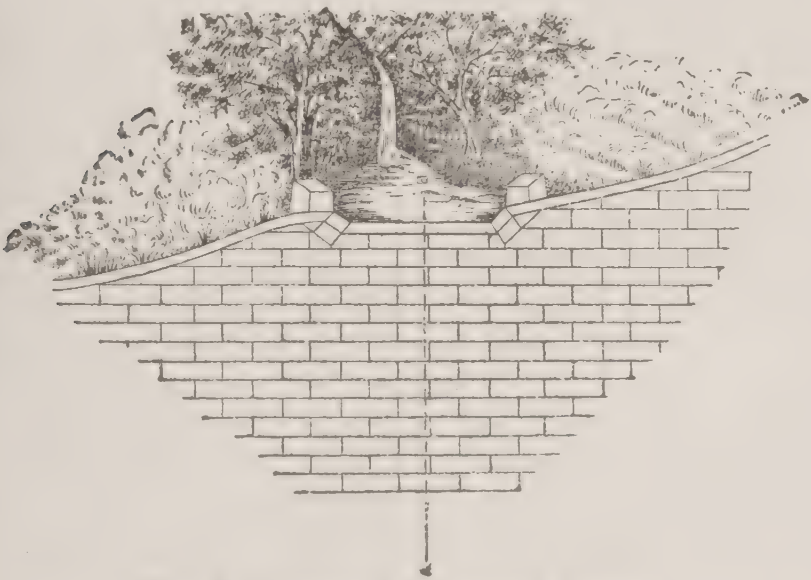


Fig. 8.—Causeway at Mountain Stream.

rounded the spur and is again leading in towards a hollow, it must be sloped inwards, and have a drain, because the continuously contracting character of the ground forces any water that falls to concentrate, and it must be so dealt with. Wherever a drain is considered necessary, the road must be made to slope inwards for the following reason: in the early stages of the monsoon

it is not unusual to have a sudden burst of very heavy rain after a spell of continuously dry weather; some rubbish or jungle may have got into the drain here and there and been neglected; the first burst of the flood comes rushing down the drain, gathering the rubbish in front of it until there is quite a heap being carried along; this meets with some obstacle at a bend of the road perhaps, and finally forms a block, when the water bursts over on to the road. Now, if the road slopes inwards, this water will merely go round the block and back into the drain at a point further down the road, the only damage being a rut in the road, which can easily be repaired; but if, in such a case, the road slopes outwards, the water from the blocked drain rushes clean across it and down the cultivated land, resulting in havoc and destruction, more or less complete. Hence, it may be laid down as a definite rule, that when a road slopes outwards it must have no drain on the inner side.

CULVERTS ON HILL ROADS

The making of culverts or small bridges on hill roads should, if possible, be avoided. It is sometimes necessary to have a culvert for a drain crossing the road, but in every such case the culvert should be made much larger than is required for the normal flow of water. Culverts have a nasty habit of getting blocked with rubbish in a sudden flood, and then woe betide the road, and the land also if newly dug.

Outlets should be made for drains at intervals as frequently as possible; advantage can be taken of streams or of rocky jungle land for this purpose. It is dangerous to carry a drain for any great distance without a suitable outlet.

CROSSING STREAMS

The crossing of small streams is one of the most important matters in hill road-making. No bridging should be attempted, the most efficient and permanent

system is to build up a causeway from the bed rock, and let the water flow over it. Avoid anything like a contracting drain. Let the water spread out as much as possible.

When the chasm to be crossed is rather deep and wide, the building may be in the form of a causeway, leaving a basin on the upper side; this takes less stone than building the whole thing up, and in time becomes fully as strong as if the whole basin had been filled up with stone. (*See* illustrations, Figs. 8 and 9).

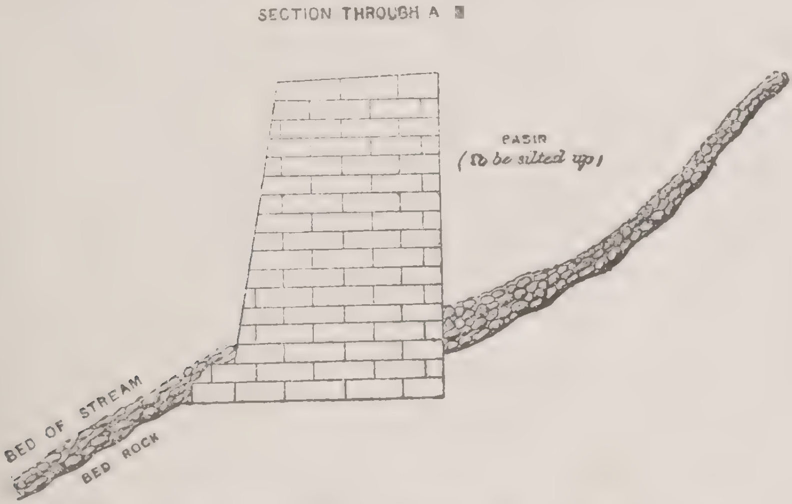


Fig. 9.—Section through Causeway at Mountain Stream.

The water will at first flow through the wall, but as soon as the monsoon comes on, the first flood brings with it a quantity of stones and silt, which fill up the basin; the water then flows over the top of the wall, as intended, and the building becomes firm and permanent, the basin full of silt forming a cushion behind it.

Such building work should be with dry stone only—no mortar.

REVETMENTS

Revetments are always more or less expensive and are often very unsatisfactory; hence in road-making, it is advisable to avoid building, unless where absolutely

necessary. Even when a landslip has carried away a piece of road, it is usually better to cut back into the solid ground for a new track, rather than to build up in front. A roadway cut into soft rock is always much

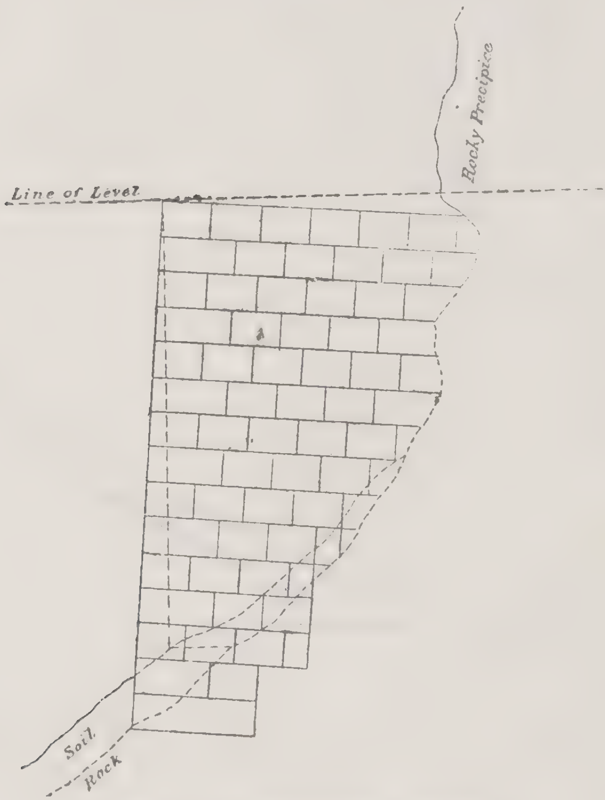


Fig. 10.—Revetment Correct.

preferable to a built gallery sticking out from the hill-side. It may be necessary in many places to build a small revetment on the upper side of the road. For such revetments, of course, a perfect foundation can be got on the road itself, and the work will give no trouble.

SLOPE OF BANKS

Earth banks everywhere should have a slope of not more than 50 degrees from the horizontal. Sometimes it is necessary to build a revetment in front, and in such cases a good deal of supervision is necessary to ensure good

permanent work being done. The coolie is inveterately fond of building upon sand, hence the importance of seeing all the details of this work carried out on sound principles.

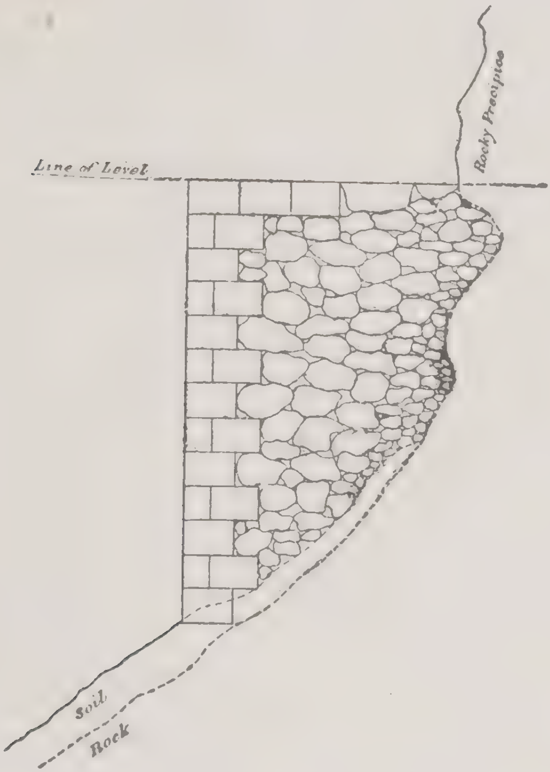


Fig. 11. Revetment—incorrect.

The accompanying sketches show a revetment in section. Fig. 11 shows how it should not be done, and Fig. 10 shows the proper form of building. The following points require attention :—

First.—There must be a good foundation, right down on the rocks, on which a bed sloping inwards should be cut. The manager or assistant should inspect the foundation after excavation and before a stone of the building is laid.

Second.—The face of revetment should be made to a slope or batter of about 1 in 10 from the perpendicular.

Roughly built revetments should slope 1 in 6.

Third.—The building should be in regular courses. The courses to be not level, but at right angles to the face of revetment.

Fourth.—The courses should be carried right back, native workmen usually build a mere veneer of good stone, and simply throw in rubble behind.

Fifth.—Avoid filling with soil, which retains water, and becomes a source of danger.

BUILDING WITH MORTAR—WEEPING HOLES

Generally speaking, dry stone revetments are as strong as there is any possible need for; if, however, good stone cannot be obtained, it may be necessary to use lime mortar in order to bind the small stones together. In such a case it is imperatively necessary to have weeping holes, to carry off any water which may get behind the building. These may be 6 by 6 inches reaching right through the wall: they should be introduced in every third or fourth course, and about every four feet apart.

In recent years developments in the use of reinforced concrete have made much easier the task of guiding water through the channels in which it is meant to go, than was the case 30 years ago. It is well worth the trouble of seeking the advice of experts in the construction of culverts, revetments, bridges, etc., if sound local advice on these matters is not available.

CHAPTER XI

UTILISATION OF ESTATE LAND NOT OCCUPIED BY TEA

MOST Tea Estates in N. E. India have grants of land exceeding considerably the actual area occupied by tea bushes, buildings, roads, labour lines and gardens, and so forth. Many estates, especially during the past 8 years, have utilised such waste land as is suitable, for growing food crops for the labour, for growing fuel trees, and for plantation of subsidiary cash crops such as Tung. A few have experimented, in some cases quite successfully, with the growing of such crops as tobacco, flax, derris elliptica, grass and tree fodders, oats and other grain, ground nuts, etc.

Much of the land not occupied by tea, or by forest, swamp, etc., is utilised by the garden labour as grazing land for their cattle, but seldom is much attention paid to the maintenance of this land, and it is generally poor, and inadequate to the needs of the livestock which it is intended to support.

CLASSIFICATION OF NON-TEA LANDS

Land not used directly in the culture of tea may conveniently be classed as follows :—

(1) Forest land.
(2) Swamp and land unsuitable for growing tea, forest or other crops, and unsuitable for grazing.
(3) Grazing land.
(4) Land suitable for food or cash crops and fodder crops.

FORESTRY

IN the early days of tea, when firing of boilers and driers was almost entirely by wood, no tea estate could

afford to be without forest. Apart from timber for building purposes, it was estimated that one ton of wood fuel was required for every six maunds of tea made, as a rough approximation. Nowadays, the use of coal and oil as fuel, and the general use of steel and concrete for buildings, have made the need for wood reserves very much less urgent, but by no means unnecessary. The labour require wood fuel for cooking, etc., and if no forest is available, may cause considerable damage by lopping branches from shade trees, which are often enough difficult to establish and maintain.

WASTE OF FOREST

It is pitiable to think of the hundreds, and even thousands, of acres of valuable forest which have been recklessly and needlessly swept away from many estates in all the tea districts. This has resulted either from the carelessness of those in charge, from inability to appreciate the value of the property, or from sheer ignorance of the general principles of forestry.

EFFECTS UPON CLIMATE

The experience of the Forest Department in India has added testimony to the fact, which has long been known, that the deforestation of a province has a very marked effect upon liability to floods, and to increase in soil erosion, while, if the whole country is completely denuded of forest, the result is practically ruin, at least from an agricultural point of view.

FOREST RESERVOIRS—EVAPORATION

When the monsoon pours its beneficent showers over the country, the portion which falls upon open ground soon disappears. Part of it sinks into the soil, while part is at once carried off by streams and rivers to the sea. The rain which falls upon forest land is received into a sort of reservoir; it is detained by dense vegetation from flow-

ing rapidly off the surface; it is retained by the mass of roots underground; and it sinks down deeper than in open country. This retention of rainfall by forest areas minimizes the extent of flooding of lower lying open land after heavy rain. The sudden rush of water which would, on land covered with jungle, be released gradually, may cause widespread destruction of crops and property. When dry weather sets in, the deforested areas get rapidly dried up; whereas it has been proved by actual investigation that the evaporation from forest land is from 62 to 84 per cent less rapid.

EROSION

Whenever forest land is cleared for agricultural purposes or otherwise, and the soil left unprotected, erosion of some form or other is bound to occur, even on the gentlest of slopes. Furthermore, stirring of the soil is unavoidable at some time or other, with all agricultural crops, and this is an operation which inevitably increases loss by soil erosion unless elaborate methods are employed to prevent it. Many examples of the effect of deforestation on soil erosion have been cited by agriculturists in various parts of the world.

HILL FORESTS

In mountainous regions, the necessity for a large area of forest becomes all the greater, for experience has proved that where too large a proportion of the mountain sides has been cleared, the steeper slopes become much more liable to suffer from landslips during heavy rain, there being nothing to hold the water in check; the streams become torrents, and the rivers develop into devastating floods. All the water being thus rapidly drained off the land, the dry weather becomes a season of severe drought, during which all classes of cultivation suffer more or less.

From all this it follows that when people become possessed of great tracts of hill country and then proceed to destroy all, or nearly all, the forest thereon, they not

only court disaster for themselves, but they also cause serious damage to all neighbouring property.

EFFECT UPON DIVIDENDS

Apart from these wider considerations, the existence of suitable forest, in good yielding condition, has a very real and immediate effect upon profits and dividends; hence some knowledge of forestry is quite imperative for the manager, who is to work his estate to the best advantage.

SYLVICULTURE AND ARBORICULTURE

Sylviculture refers to the preservation and protection of existing forest; fencing where necessary, cutting creepers which threaten to strangle trees, preventing grazing and fires, thinning out, etc. Arboriculture involves the planting of new forest, or planting up of bare patches, and otherwise making use of waste ground for forest purposes.

On many tea estates, sylviculture is all that can be attempted, but even in the matter of planting new land it is wonderful what a lot can be done with a very small expenditure, or with practically no expenditure to the estate, because the labour at this work is expended mostly at a time when there is nothing else pressing for attention. In this matter what is required is knowledge and care on the part of the management, rather than expenditure of any considerable sums of money.

GRAZING

Grazing, or rather browsing, is of all things most destructive to forests, short of actually cutting down the trees. The worst browsing is that of buffaloes, cows next, and goats a good third. If any considerable number of animals are allowed to graze in a piece of forest, it is quite hopeless to expect young trees ever to come up to take the place of the mature ones which die or have to be cut down:

hence no coolies should be allowed to keep grazing animals, unless perhaps on grass land, or on a suitable block set apart for the purpose. Cowherds are very fond of cutting down the branches of certain trees for stall-feeding, and if allowed to do so, they soon cause great damage and destruction.

COWSHEDS

On no account whatever should cowherds be allowed to build sheds in any part of the forest, because the immediate effect of this is a rapid and complete destruction of practically every living thing in the neighbourhood of the hut.

FIRES

At the dry season of the year there is great difficulty in preserving forests from unintended and uncontrolled fires, the more especially as all cowherds make a practice of firing land where their animals are allowed to graze, in order that they may get the fresh young grass and herbage which springs up almost immediately after a fire has passed over the land. When once such a fire has been started it may spread and stretch away for many miles if not checked. Wherever the fire goes, it destroys at least seventy-five per cent of all the young saplings, besides more or less seriously damaging the bark of large trees. The few saplings which are not actually killed emerge from the ordeal in a very crippled state, and so damaged that it is doubtful if many of them will ever develop into good sawing timber.

FIRE LINES

As a protection for standing forest, as well as thatching grass, etc., it is often necessary to cut a fire line all round it in the autumn or early winter; this will soon dry artificially, and can be burnt before the grass of the preserve itself is dry enough to ignite; so in this way a line

or a ring of bare ground is formed, which becomes a zone of safety from the inroads of fire from neighbouring properties.

CREEPERS

Many fine young timber trees are killed or maimed annually by the action of enormous creepers which gradually thicken and tighten their grip till they have obtained the mastery. It is the custom of the Indian Forest Department to send a few men round the forests once a year, with hatchets, to cut such creepers; one snip with the hatchet is usually enough to rid a young tree of its enemy for a good many years at least.

It is a mistake to suppose that the best way to preserve or improve a forest is by simply letting it alone.

VALUE OF CROPPING—SEED TREES

In most cases a little cropping where judiciously done, results in great improvement; it must, however, be done systematically and under proper supervision. When trees come to maturity and reach a certain age, they practically cease to increase in bulk or produce timber, and are taking up ground which can be occupied to better advantage by new seedlings. For this reason it is advisable that mature trees should be made use of from time to time, and the young seedlings around get a chance to expand. In cutting out mature trees, one important matter has to be borne in mind; a supply of seed is always necessary for renewals by self-sowing in the forest, so that if all mature trees are removed, the future of the forest is sure to suffer; hence at least one large tree must be left at intervals in order to secure the necessary supply of seed.

CANOPY

Where young forest has become at all dense, it is very important to have the trees thinned out to a suitable distance; care must always be exercised to avoid extremes

in this matter. Foresters make it a rule to preserve as nearly as possible a complete canopy of foliage overhead. It is always reckoned a test of a carefully worked forest that no great portion of sky can be seen from any place on the ground. In thinning out, of course, all the worse kinds of trees as well as crooked and crabbed specimens will be taken out by preference.

WORKING PLANS

If a forest is to be worked to the best advantage, it is quite necessary to begin by framing a working plan by which a definite portion will be treated annually, leaving the remainder untouched, so that the whole may be gone over the routine during a cycle of years. Even in the matter of cropping bamboos, if the details of the work cannot be carefully watched, a great deal of good will be done by confining the cutters to certain blocks of forest in each year, giving the other blocks time to recover from any injudicious or rough treatment to which they may have been subjected.

COPPICING

In some cases a scarcity of financial resources may perhaps render it necessary to crop young forest for fuel to tide over a temporary difficulty. It will then be advisable to coppice the trees, that is to cut them down at about five feet from the ground, with the intention that the stumps should throw out new branches and again become trees. This is often done with great success in some parts of England. There are some kinds of trees which stand coppicing very well, and produce in course of time perhaps as heavy a weight of timber for fuel, etc., as those which have been left to grow in natural form from the first; but it must be remembered that such trees can never be expected to form into thick timber suitable for sawing into beams and rafters for building purposes.

The ideal system of coppicing is that the trees should be cut down close to the ground in which case the new

shoots which develop spring from the level of the ground, and soon form roots of their own, so that in this way each new shoot becomes practically a new tree, irrespective of the stool from which it has sprung. The one drawback to this is that not every kind of tree can stand such severe coppicing; and if there is danger of the tree itself dying under the operation, it is better to coppice high. It is only by actual experiment that a decision can be made as to whether in any case the trees may be safely cut down to the ground. One tree which is reported to be suitable as fuel and which will stand coppicing is the *Cassia Siamea*. Many trees, under sub-tropital conditions, however, rapidly become diseased, and die after being cut down.

STANDARDS

According to the experience of Indian foresters, it is not advisable to coppice the whole of the trees in any block at one time; it is better to leave what are called standards at frequent intervals. This means that trees are to be left standing untouched at intervals of not more than forty or fifty feet, in order to provide some shade for the new growth when it begins.

For the purpose of coppicing, it is a good plan to divide the forest into about twenty blocks; then each year one block is to be coppiced in succession; so that, by the time that the turn of the first block comes round again, there will be sufficient new growth for recutting. The coppicing should be limited to trees having a girth of not less than eighteen inches.

GIRDLING

When it is intended to cut mature timber either for sawing into scantlings or for fuel, it is very desirable that such timber should be thoroughly dry before being put into use. The usual custom is to cut while green and stack it to dry; a cheaper and much more efficient way is to girdle or ring the standing trees about a year before they are required, or even a month or two before; if the

trees are of a soft nature, they will then dry themselves almost completely before the circulation of sap ceases. Ringing or girdling may be described thus. A belt of bark is cut off the trunk of the tree at a point near the ground, the ring of bark measuring about eighteen inches wide right round the trunk; a deep ring is then cut into the sap wood all round the centre of this belt, but this ring need not be wider than a few inches. The sap of the tree continues to rise as before up the channels in the sap wood of the trunk and so on to the branches and leaves, then starts on its return journey down between the bark and sap wood, but is arrested at the point where the ring has been cut away, and so being prevented from returning to the roots, it is carried of into the atmosphere by evaporation. This process of partial circulation goes on until practically the whole of the sap in the trunk and roots has been extracted and the tree expires. A curious fact in connection with this matter is that, if a comparatively young tree is cut clean off, it will almost certainly grow again from the stump, but if it is ringed in the manner described above, a gradual decline and death is sure to supervene.

There are some kinds of trees, however, with soft and very sappy wood, such as the Simal, which are difficult to kill even by ringing, because the flow of sap downwards from the upper edge of the wound is so abundant that it soon bridges over the gap at one or two points, forms new bark over the wound and so establishes complete circulation again.

PLANTING TREES

If it is intended to plant out new forest or to fill up open spaces, a great deal of labour and disappointment as well as expense may be saved by first considering well as to what particular kinds of trees may be planted with a prospect of success. It would be folly to try to plant on a large scale anything which would be unsuited to the climate of the place, while, on the other hand, it would be almost equally foolish to plant trees of low value and of

very limited usefulness, merely because the planting would be easy.

A valuable guide to those who intend carrying out work of afforestation is a booklet "Nursery and Plantation Notes for Bengal" by C. K. Homfray, B.A., I.F.S., published in 1937 (4th Edition). In this publication it is pointed out that certain species of tree "are suited to certain localities, and a knowledge of habitat is essential for successful regeneration". By studying the types of useful trees growing locally, a selection of those trees likely to be most successful under the particular soil and climatic conditions can be made. In this, and in many other aspects of forestry, the knowledge and assistance of officers of the Indian Forestry Department should be sought, and such help may avoid much fruitless work and waste of money.

WILD SEEDLINGS

Sometimes really good and useful kinds of trees may be found growing in neighbouring forests, and it will always be safe to make use of the best kinds of these. It is doubtful policy, however, to transplant from existing forests any seedlings which have grown up from seeds self-sown. These are necessarily delicate, having grown in the shade of trees and shrubs, and their roots but ill-developed because of the entire absence of cultivation.

NURSERIES

It is better, where necessary, to make small nurseries here and there, as near as possible to the required spot, and grow the plants from fresh seed. The seedlings may afterwards be transplanted during the rains, or during the cold weather with large unbroken balls of earth, the latter for preference.

CASSIA SIAMEA

Cassia Siamea has been grown successfully on tea estates as a fuel tree. It is fairly quick growing and can

be pollarded at about 4 foot from the ground when the trunk is about 4″—6″ diameter.

GREVILLEA

The Grevillea or Silver Oak is recommended as a most useful tree for any moderately warm climate, and can be grown even at an altitude of four or five thousand feet. It grows rapidly, has a very handsome appearance, and yields excellent timber either for fuel or for building purposes. It is, however, slow of germination and difficult to handle. Seed is not plentiful and is therefore rather expensive. In some climates the Grevillea is liable to a fungus blight which attacks the leaves, and eventually kills the young tree. Dusting with sulphur is a preventive. The tree thrives well in rich light soil, or with abundance of manure.

OAK—WALNUT—PINUS LONGIFOLIA

For hill estates the various kinds of Oak and Chestnut are always good; some of the varieties indigenous on the Khasia Hills grow very rapidly, yielding excellent timber, and have been introduced to other districts with great success. There are different varieties suited to different altitudes. Khasia Oak does not succeed on poor soil. Walnuts also grow easily and rapidly without much trouble at elevations between 3,000 and 6,000 feet. The best method to grow Walnuts is to put the seeds into germinating beds about November. They sprout in February or March, when they can be planted out with certainty of success. The Walnut grows very rapidly in good soil. The Sikkim Walnut has a very hard shell, but germinates readily without any special treatment. The timber from it is very valuable. Pinus longifolia grows well in some hill districts, yielding good timber for boards. It grows at an elevation of 1,000 feet upwards.

CRYPTOMERIA

Cryptomeria grows readily in hill climates, but the timber is not greatly valued. It does not make good fire-

wood, although the young branches burn well. All the conifers grow readily in poor soil, if well drained.

TOON

There are some kinds of trees which have to be reared in nurseries and are improved by transplanting, but there are others, such as the Toon or Indian Cedar, which do not stand transplanting at all well. The Toon tree yields such a valuable timber for box boards, etc., that it is worth a good deal of care and expense in order to rear it satisfactorily. It grows on the plains, and up to 4,000 feet. The most successful way to plant Toon is to form little thullies or spot terraces on the spots where the trees are to grow; after a shower of rain sprinkle a few seeds (which are very small) on the surface of the ground, cover lightly with fine soil and then with some soft grass to keep off the rays of the sun. When the seedlings come up, thin out and keep free of weeds. Keep off all goats or similar animals, which are all exceedingly fond of toon leaves. Toon may also be transplanted successfully in the cold season with unbroken balls of earth.

Perhaps the best tree of planting on the hills is the pipli (*Bucklandia populnea*). It grows rapidly, even on poor soil, is evergreen, and one of the handsomest-looking trees of the forest. The timber is very valuable, almost as hard as Sal, and finer grained. It stands shade well, but cannot be grown at all where grazing is allowed, as the young trees bleed almost to death every time the tips are eaten off.

DIBBLING

There are some kinds of trees, such as the Oak and Walnut, which do not require to be brought up in nurseries, and are indeed much better to be sown, *in situ*, by dibbling. Sometimes they are first germinated in hotbeds, but even this is not necessary if the seed is quite fresh and climate or land is at all moist. The experience of the Forest Department has gone to show that walnut

seed, if fresh, scarcely ever fails to germinate. It is merely dibbled by placing in a hole, "shell and all", as it is, and covered with an inch or so of soil.

MIXED FORESTS

Forests composed of only one kind of tree always look best, but better ultimate results are obtained by planting various kinds together, because different classes of trees extract different kinds of nourishment from the soil, and with a mixture all the soil constituents are made use of to their full extent.

DISTANCE APART

Trees should be planted quite close at the start, say 5 × 5 feet, and thinned out afterwards as they develop.

The importance of this is that they draw one another up and form straight boles. If too wide apart they will develop side branches, which is very undesirable, in trees to be used for timber.

SCRUB

Planting up bare land is a very difficult and slow process because most forest trees naturally require some shade, and the young plants become stunted by exposure to the full rays of the sun. One plan is to plant scrub forest first; which is formed by putting in cuttings or seeds of rapid-growing, indigenous scrub; then the timber trees are planted at regular intervals. A crop of boga medeloa or some other leguminous shrub in lines is probably the best means of shading the soil and young saplings, and at the same time, a crop of this nature enriches the soil in fertility and improves its physical condition. Perhaps the best arrangement for the trees is to plant lines 20 feet apart, and 5 feet between the plants in the lines. This allows ample for failures and the trees will ultimately be thinned out to about 20 × 20 feet.

CAPITAL COST—OVERCROWDING

In planting forest, a very important consideration is the amount of original expenditure. Many foresters advocate planting trees very closely, even 2×2 feet at the start; but when it is reckoned that the forest cannot yield any return till after the lapse of several years, and there cannot possibly be any sawing timber till after many years have elapsed, the original expenditure may by that time become a very serious item. Even a moderate sum at compound interest for 20 years figures out at a very large amount. In most circumstances the expense of planting closely, all things considered, renders it quite prohibitive. The closer the planting, and the longer the delay in thinning out, the more certainty of ultimately growing tall, straight trees with clean boles; but at the same time, the growth is proportionately slow, because the roots of all the trees are contending for the small amount of soil available, and the growth of one and all is retarded. In all kinds of agriculture it is now a recognized fact that overcrowding is a serious hindrance to root growth and plant development.

THATCHING

Every tea estate should have a good supply of thatching grass; if none is found on the place, it should be planted without delay. It may, of course, grow on poor land, but it cannot succeed well or yield good crops year after year unless on good soil. A hot, dry climate is best.

TIME OF CUTTING

Thatching grass should be cut when fully ripe, but must not be allowed to stand until it begins to redden and decay; in this case it will not last long or make good thatch. It may be cut and left to dry for a few days on the ground, then bundled and brought in. If bundled in a green undried state, it will ferment and spoil, or if stacked in great heaps, the same result will follow. The bundles may be made to stand on end, supporting each other in a circle until required for use; if rain falls mean-

while, care must be taken to have the bundles turned over and dried before rotting sets in.

CULTIVATION

Thatch fields require to be annually cleaned of extraneous plants and roots, shortly after reaping, and an occasional burning and a rough digging greatly improves their condition.

BAMBOOS

Bamboo finds extensive use on tea gradens for fencing, building, bridges and in many other equally important ways, so that a few notes describing briefly the botany, distribution and cultivation of the more generally known kinds may be of interest and of use to tea planters.

Bamboos belong to the sub-order *Bambuseae,* a section of the great natural order of the grasses (*Gramineae*). *Bambuseae* are divided into 23 genera, of which 15 belong to the Indo-Malayan region, the remaining 8 being chiefly American. The 15 Indian genera comprise 115 species of bamboos but many of these are either rare or else entirely useless for any practical purpose.

The distribution of bamboos depends on climate, and it is only tropical and sub-tropical regions which favour natural growth. In Europe there are no natural growing species.

The stems or "culms" of all bamboos are more or less cylindrical, almost always hollow, and separated by partitions which are called nodes, the intervening spaces being termed the internodes. These latter vary considerably in length, the longest being about 50 inches. Those types of bamboo having long internodes are more suitable for fences, wicker and all kinds of interwoven work, while for building and posts, bamboo with short internodes is more suitable on accout of its strength and rigidity. The thickness of the stem-wood of course determines the suitability of otherwise of the bamboo for building.

The height and diameter of bamboos varies between 100 to 120 feet in the "wabo" (*Dendrocalamus giganteus*), having a culm diameter of up to 12 inches ; and, in the case of the *Arundinaria densifolia*, a height of 3 feet only, and culm diameter of ⅓ inch. Bamboo culms normally grow at a rapid rate, the larger types often reaching a height of about 50 feet in a month.

The bamboo culms arise from rhizomes, or underground stems, to which are attached the roots proper. In nearly all species of Indian bamboo, these rhizomes are massed together in a thick knotted clump, from which the stems arise, but in some species, as for example the "muli" bamboo (*Melocanna Bambusoides*), the rhizomes push their way underground sending out rootlets and stems singly at intervals. This latter type of bamboo is often responsible for the incredibly rapid covering of a hill-side with bamboo.

The stems or culms as they grow, throw out sheaths at each node. The sheaths which are green at first and covered with black hairs, gradually turn brown and fall off. As these sheaths are shed in the second year of growth, side shoots develop from the nodes and bear the true bamboo foliage. Most bamboos bear culm sheaths which are in shape, size and texture, characteristic of the particular species. The leaves of all species of bamboo are generally very similar and are of little use in distinguishing various species.

Very few species of bamboo flower annually, while in most cases flowering seasons come at very long intervals, when the whole of one species in a district may (if, as is likely, they are offsets from the same original clump) flower at the same time and die down after giving seed. Even those species, like the giant "wabo", which may also flower sporadically, give at such times only a small quantity of poor seed while the general flowering will give a large quantity of very good seed.

Owing to this very infrequent flowering, our knowledge of many species is incomplete, since their flowers and fruit are as yet unknown.

DISTRIBUTION

Of the seven principal physiographical regions of India and the Malay Peninsula, almost the whole of the tea districts of North-East India lie in region No. 5 (Gamble), i.e., Bengal, North-East Himalaya and Assam. In this region the most characteristic bamboos are the kokwa (*Dendrocalamus Hamiltonii*) in the north, jati (*Bambusa tulda*) in the middle region, and the muli (*Melocanna bambusoides*) in the south. Besides these three indigenous species there are at least 46 other species which have become acclimatized.

USEFUL TYPES OF BAMBOO

The types of bamboo which have become well known in connection with the tea industry are as follows :—

1. *Bambusa tulda*. Local names :—Jati, deobans, nalbans and jao (Assam), mirtenga (Surma Valley), jowa, tulda (Bengal), matela and kiranti (West Dooars). This species is 20 to 70 feet in height having stems 2 to 4 inches in diameter with fairly thin walls, ¼ to ½ inch thick. It is the ordinary bamboo used for fences and roofs and, on account of the fact that the nodes are fairly wide apart, is very pliable when split up, and is used for all kinds of interwoven work.

2. *Bambusa balcooa*. Local names :—Bholoka (Assam), balku-bans (Bengal), boro-bans (West Dooars). This is probably the most useful bamboo in India and grows to a height of 50 to 70 feet with wide and thick stems, 3 to 6 inches in diameter and up to 1 inch or more thick. Its nodes are generally much closer together than is the case with the above-mentioned species and it is on this account invaluable for building posts, scaffolding and bullock carts. A thinner variety of this species is called in Assam the bhaluki-bans (female bamboo), the thicker variety being regarded as the male bamboo. Some specimens of bhaluki-bans have however been identified as *Bambusa teres*.

3. *Melocanna bambusoides.* Local names :—Muli (Bengal and Surma Valley), tarai (Assam) and often referred to as the terai bamboo.

The roots do not bunch together but spread out under the ground throwing out stems at intervals. This species is common on teelas in the Surma Valley.

It grows to a height of up to 60 feet, has a stem diameter of 2 to 3 inches but is very thin walled, 1/5 to 1/3 inch thick. It is used extensively for walls and thatch roofing and is generally stated to be unattacked by white ants. Its nodes are up to 20 inches apart and are not so prominent as in most other species.

4. *Dendrocalamus Hamiltonii.* Local names :—Chye (Dehra Dun), kaka or kakwa (Assam and Bengal). This is a tall bamboo reaching 70 feet or more in height, and 4 to 6 inches in diameter, with fairly thin walls (½ to ¾ inch thick). It is common in Darjeeling, Terai, Dooars and Assam, but not well known in the more southerly regions.

Its softness and thin walls make it less useful for building than the bholoka and jati, but it is used to a great extent in basket and mat work. *D. Sikkimensis* and *D. Hookeri* are very similar bamboos and are often confused with the kakwa. The first-mentioned is used in the Darjeeling district for making vessels for carrying water and milk.

5. *Dendrocalamus giganteus.* Local names :—Worra (Assam), wabo (Naga Hills and Burma). This is the giant of the bamboo tribe, specimens often reaching 100 feet in height and 8 to 12 inches diameter, with thin walls covered with a white waxy scurf when young.

It is sometimes confused with other similar species such as *D. Brandisii* and *flagellifer.* It is often used for making vessels and water pots, particularly in the Naga Hills.

6. *D. Mastersii.* Local name :—Bheti-bans (Assam). A small reed-like bamboo with a solid stem $\frac{1}{2}$ to $\frac{3}{4}$ inch diameter used for making sticks, umbrella handles, etc.

Other bamboos in use are the *Bambusa pallida* (mokal, khora, bijli, in Assam; bakhal in Surma Valley; pushee and bonshing in Darjeeling), 40 to 60 feet high, with stems 2 to 3 inches diameter, with thin walls, and is used for fencing and basket making. *Bambusa nutans* bears the same Assamese local name but is rather larger. It is used for the same work as the *B. pallida*. Another valuable bamboo in Assam is the bajal (*Pseudostachyum polymorphum*), a long thin bamboo only an inch in diameter and very thin walled. It is used for basket work in tea gardens and for mats. There is also the kanta-bans, kota or kata (*Bambusa arundinacea*), a "jungle" species, having long spikes projecting from the nodes, and is therefore difficult to cut, but makes a good fence. It grows high and thick culms, which are however crooked and knotty and generally unsuitable for every-day use.

Arundinaria Griffithiana and *A. callosa* also bear spikelets, and the local names kanta-bans, kata, and kota may also be applied to these species.

Since one local name is often found applied to several different species of bamboo having similar appearance and practical application, it is impossible in all cases to apply definite local names to definite species.

PROPAGATION

There are four methods of propagating bamboos of which two, namely, from seed and from off-shoots, are of importance.

As mentioned previously, seed from a general periodic flowering is best for propagation, seed from a sporadic flowering being often weak or sterile. The seed is encased in several layers of husk and is actually very small in size in most species. When planted fresh it germinates in two to three weeks. The seed should be put out in a nursery of rich moist soil, about 12 inches apart and when the plants have come through, the use of thatch as shade, spread on chungs 3 to 5 feet from the ground, is desirable, in the drier districts.

After two years the plants may be transferred to the bamboo plantation, the planting being at intervals of 20 feet with a liberal supply of cattle manure.

In propagating bamboo from off-shoots of the older parent bamboo clump, care should be taken to use only one year to 18 months old off-shoots. These should be selected from the outer ring and cut at 8 to 10 feet from the ground just above a node. The soil is carefully removed round the roots and the main root or rhizome cut away from the parent stock, leaving as much root as possible with the off-shoot. Care should be taken to do as little damage as possible to the rootlets. The off-shoots are then immediately planted out in the new clearance 20 feet apart in pits containing a mixture of soil and manure in equal quantities. The root should be buried so that one node of the stem is just below ground, and the soil should be firmly embedded round the plant. The stem should point north at an angle of 45° to the ground. This lessens the drying effect of the sun on the stem, and if the top is covered with a cake of cattle manure the drying effect of the sun on the open cut is lessened still more. If a stem dries up it may split and die right down to the root and the plant may fail to grow, or at best may come away very slowly.

In most common bamboos, the stem sheaths attached to the nodes of young stems are green and are covered with black hairs. The sheaths turn brown after one year and fall off. It is therefore easy, by selecting stems which bear brown sheaths on the lower nodes, to make sure of using off-shoots not more than 18 months old for propagation. The most suitable time for planting is in March and April, in the plains.

The advantages of off-shoot propagation over seed propagation are, firstly, that yielding clumps are obtained a few years earlier ; and, secondly, that the cost of propagation is less, as no nurseries have to be prepared. The chief disadvantage lies in the fact that the parent bamboo may be near its general flowering period, i.e., its death, at which time all the bamboos propagated from its off-shoots will flower and die. In the case of seed propa-

gated bamboo, a long period can be guaranteed before a general flowering will take place.

Two other methods of propagation are by layering and by cuttings. In the former case, a stem is bent over from the clump and a portion pegged under the ground. When roots develop at a node on the portion below the ground, the stem may be cut from the parent and the excised piece may be removed and planted elsewhere, care being taken not to damage the newly formed roots. This is a tedious and not very successful method. Propagation by cutting is similar to the method of using off-shoots, except that no care is taken to see that a portion of the roots is removed with the stem, the lowest node being relied on to throw out roots when placed in the ground. This method results in a large percentage of failures and though rapid and easy is not recommended.

MAINTENANCE OF BAMBOO PLANTATIONS

Bamboos grow well on any soil which is suitable for tea, i.e., a well-drained fairly-rich soil. The common useful types will not grow on land having a tendency to waterlogging. The peculiar formation of land known in Assam as *Korkani*, in which the soil is cut up by irregular ditches and holes, is very suitable for bamboo. Tea suffers from close proximity to bamboos, which should be at least 15 feet from the nearest tea bush, and separated by a drain or trench not less than 3 feet deep.

Cattle manure is a valuable manure to apply to a bamboo clump in the early stages of its development. Since like other plants, bamboos are very adversely affected by growth of jungle, the young plants and off-shoots should be clean weeded regularly till they become large enough to keep the jungle down themselves by virtue of their shade.

CUTTING AND PRESERVING

A bamboo stem is ripe for cutting after it has had two years' growth and should not be left uncut after three

years. If taken younger than two years, the wood is soft and does not respond to treatment commonly employed for hardening. For permanent work such as building and carts, bamboo should be soaked for a month in water in order to harden the stems. It is generally considered that the muddy water in an adjoining water-course or "hoolah" is most suitable for this purpose. Care should be taken not to allow continual cutting of the outside stems of the clumps thereby leaving the inner ones to form a thick mass which is difficult to deal with. Bamboo stems should be cut out of the clump so as to leave the younger stems evenly spaced out. One clump should give under reasonable care in treatment, an annual yield of up to 20 bamboo stems.

The ordinary coolie knife is unsuitable for cutting bamboos and a good instrument can be made from a piece of steel 1 foot or more long, 2 inches broad and $\frac{3}{4}$ inch thick, flattened to 3 inches wide at one end and sharpened like a chisel. This implement is driven into the side of the stem and used like a crowbar.

The very young bamboo shoots are edible, especially when boiled, but their removal from the clump, apart from the loss of future bamboos entailed, is itself harmful.

PESTS AND DISEASES

There is a species of rat which eats the shoots of bamboos and unless destroyed along with its nest, which is found in the middle of the clump, can cause much damage to a bamboo plantation. Hares also at times eat the young bamboo shoots.

Bamboos do not seem to suffer much from insect pests or diseases, though there is one insect, the grub of which feeds on the roots of bamboo clumps causing them to die out.

USES AND PRODUCTS OF BAMBOO

The main uses of bamboo are so widely known and so numerous that it would be unnecessary and tedious to deal in detail with them here. For tea garden work,

bamboo finds application in building, fencing, bridges, revetment of drains, making posts and frames for support for nursery shade, and for plucking baskets.

Attempts in the latter part of the nineteenth century to employ bamboo for paper making were frustrated by economic and practical difficulties. Otherwise wise there is no doubt that the bamboo is capable of yielding a "paper stock" of the highest quality.

CONSTITUENTS OF BAMBOO SEED

The bamboo seed forms a highly nutritious foodstuff and has in time of famine saved thousands of lives. It contains water 13·5 per cent; proteins 10·8 per cent; starch 71·6 per cent; oil 0·6 per cent; fibre 2·1 per cent; and ash 1·4 per cent (of this ash 90 per cent is silica).

The leaves of bamboo are valuable as fodder and are reputed to be a cure for cold in horses and cattle.

CONSTITUENTS OF BAMBOO STEM

The average of several analyses of the stem wood of jati bamboo gave a moisture content of 25·5 per cent in the case of the green stem, and of 16·3 per cent in the case of sun-dried stem. The percentage of ash, calculated on dry matter, is 1·80 per cent and of this 50·6 per cent is silica. Thus the dry wood contains 0·91 per cent of silica.

The wood fibre is very long and closely packed, a fact which accounts for the rigidity and toughness of a bamboo.

A rough estimate of the consumption of bamboos in India places the latter at about 200 million stems annually, and bamboo forms the most important portion of the minor forest produce of all forest divisions in India.

SWAMP, LAND, POOLS, RIVERS ETC.

Though land of this type is useless for cultivation, nor except in the case of buffaloes, is it of any use for grazing, it frequently supplies a very valuable item of

food for the labour in the form of fish. Seldom however is any attempt made to improve matters in this direction, though much could be done, by cleaning out suitable pools or tanks, eliminating the harmful carnivorous fish, by stocking with fry which can be obtained in many cases locally through Government Agricultural Departments, and finally by careful control of fishing. Information of great value on piscicultural practices is available from the Zoological Survey of India.

GRAZING LAND

In order to avoid deterioration of the pasture land it must not be overgrazed. An average of $1\frac{1}{2}$ acres per animal is commonly quoted as necessary, but this will of course vary with the season. In the season of rapid growth (May to November in Assam), the number per acre may be at least twice that in the dry season. It is almost equally important not to leave land ungrazed or undergrazed, as under these conditions all kinds of undesirable growth, scrub jungle, etc., gets a hold and flourishes unchecked.

There is no doubt that grass land in North East India could be greatly improved by cultural treatments such as manuring and cultivation, but it is likely that costs would at the present time prove too prohibitive for much to be done in this direction.

The cost of such cultivation however, as is necessary to suppress undesirable shrubs and jungle will be money well spent. The cutting and removal of such jungle as Futuka (*Melastoma Sp.*) and "Giant ageratum" (*Eupatorium Sp.*), helps to maintain good grazing land and the cuttings are of great value applied as green manure to tea land. On a Dooars estate large areas of old grazing land covered with *Eupatorium* were stripped of this jungle by cutting it 2 or 3 times a year for the purpose of composting. In less than 3 years time the *Eupatorium* growth became either extremely sparse or had entirely disappeared, and the grazing land was immensely improved thereby.

Experiments in other countries indicate that alkaline phosphates are generally the most effective manures for grass land but unfortunately phosphates are in very short supply and are likely to remain so in India for some years.

It is suggested however that one can manufacture a suitable phosphate by collecting all bones available and burning them with about 3 times their weight of dry wood. This can be done in home made incinerators made of oil drums. If wood is used for firing dryers in the factory, it is suggested that during the day's firing, bones are added to the furnace, and the resulting mixture of wood ash and burnt bones be collected, crushed and applied to grasslands at the rate 5-10 mds. per acre.

Soils in Assam are often too acid to grow good pasture and the application of limestone or slaked lime is worth trying, at the rate of say 20 mds. per acre. Of course, if sufficient wood ash is available, treatment with lime would in most cases be unnecessary.

When an estate is growing food crops for the labour, and food and fodder for cattle, manuring of these crops will be essential. Use will therefore be made of cut waste jungle from grazing lands (and other sources), cattle manure and straw, in the form of compost.

FODDER CROPS

These may consist of (*a*) Cultivated grass such as Guinea, Napier, Star, Molasses, etc., (*b*) Indigenous grasses found growing in waste land, nullahs, etc., such as the 'dols' in Assam :—Katanga dol and Uri-dol (which must be well withered before feeding to the cattle), (*c*) Tree fodders such as *hibiscus* and *bauhinia* species. (*d*) Silage, which may consist of any of the above fodders or a mixture of them, ensilaged at the time when the fodder is plentiful, for use in the dry season when grazing is poor and fodder in short supply.

Cultivated grasses. Guinea grass and Napier grass (Elephant grass) have been successfully grown as fodder for many years in Assam. The former is generally con-

sidered to be the better fodder, being more succulent and tender, but the latter has been used as the main fodder crop on some farms and gives much the better yield. It requires no irrigation, as other fodders (such as alfalfa) do in the dry season.

Other imported fodder grasses are Star grass (*Cynodon Plectostacheyum*), Molasses grass (*Melinis minutiflora* Pal de Beauv) also known as Venezuela, Cuban or Wynne grass. This latter grass grows well in parts of Assam, though it may be mentioned that it does not have the wonderful repellant effect on mosquitos, ticks and other insects which has been claimed for it. Its characteristic is its strong oily smell.

Molasses Grass. In the year 1943, the Assistant Agricultural Commissioner with the Government of India, supplied to the Department of Agriculture, Assam, a small packet of seeds of a grass which, according to an extract published in the Planters' Chronicle of December 1941, was supposed to possess mosquito, tick and snake repellant properties. On its first introduction into Assam, the grass used to be loosely called Venezuela grass (the grass is reported to have been discovered in Venezuela in South America) but is now known to have been identified as molasses grass (*Melinis minutiflora*, Pal de Beauv).

It has now been under observation in various parts of Assam, both in the hills and the plains. The following is a summary of the observations so far made :—

(*a*) The grass can be propagated by means of seed, cuttings and suckers.

(*b*) It grows very well as a rain-fed crop all over Assam. In the plains it continues to grow even during the winter months without irrigation, though it is expected to do much better if irrigated during the dry period.

(*c*) It flowers and produces viable seed under Assam conditions.

(*d*) It is well liked by cattle and may be regarded as a valuable addition to the forage crops of Assam.

Cultural Treatment of Fodder Grasses :

Fodder grasses generally require a well drained and well cultivated soil. Manuring is also necessary if good crops are to be obtained, and cattle manure at the rate of 100 mds. per acre is advised.

The useful method of growing Guinea or Napier grass is to deep hoe or plough the soil in the cold weather, and to plant up in the spring with small clumps, (obtained by dividing up the old large clumps) planted $1\frac{1}{2}$ ft. apart in rows 2 ft. apart. Manure is spread along the rows and hoed in when the grass has got a hold and is throwing out new growth.

Indigenous Fodders. Trials with practically every fodder crop known to grow in India were conducted a few years ago in Assam. The one fodder that stands out above all others in these trials is Napier grass, but it does not thrive in any but well cultivated and drained land. A large proportion of the waste land in Assam, where grasses can be grown, is however, waterlogged or submerged. Another kind of waste land suitable for the purpose is known as "tillas" (hillocks). Assam, therefore, needs grasses which can grow in these two kinds of waste land, more than good grasses like Napier. Another important fact which emerged from the trials, is that most of the very valuable leguminous fodders of India, such as lucerne and berseem, do not grow in Assam owing to the acidic character of its soil; and Assam has, therefore, to be content with those grasses which can tolerate an acidic soil.

The tillas are usually covered with scrub jungle and ageratum. Little use is made of them except for collecting firewood. They could, however, be made to provide cheap fodder if they were planted with fodder trees and grasses.

After trials, the Agricultural Department has selected three local grasses—*rema*, *tallia* and *dhus*—which do very well on tillas. The first two are perennials, which grow naturally to a height of 6 to 10 feet in large clumps among trees and shrubs. As the stems of these grasses are woody and fibrous, only the top portion of the stem

and the leaves are eaten by cattle. Dhus is found on the open slopes of the North Cachar hills and is known to graziers as a good grass and eagerly sought after by them. It does not require manuring or cultivation of any sort.

Another fodder plant which grows luxuriantly in hoola land which is flooded in the rains, is known in Assam as "dol grass", and "Tattua" in the Surma Valley. It has been found that these 'dols' contain about 30 per cent of protein during the spring, a figure three times that of most cultivated fodder grasses. There are two species in Assam, "Karanga dol" (*Hymenechna Assamica*), and "Uri-dol".

FOOD CROPS

Rice. The following types of rice are commonly grown in North East India—

1. Spring rice (boro).
2. Summer or Autumn rice (Ahu or Aus).
3. Winter rice (Sali).
4. Deep water rice (Aman or Bao).

Further information on the growing of these various types of rice is given in a pamphlet—"Notes on growing of Field Crops in Tea Gardens" by P. H. Carpenter and R. C. Woodford, published by the Indian Tea Association in 1943.

Unfortunately very little is known of the manurial requirements of rice and even if firms were prepared to put down large sums of money on manures one could not advise how best that money could be spent. Experiments in Bihar and at New Delhi suggest that where pulses are sown on rice land in the cold weather, manuring with phosphate increases the yield of pulse and has a beneficial residual effect on the crop of rice which follows. Nitrogen may be applied to rice at 20 lbs. per acre; bigger dressings are not advised.

Pulses. Assam is not regarded as a pulse producing Province, though there are undoubtedly large areas, especially well drained sandy areas near the Brahma-

putra and the North Bank rivers, where dals etc. can be grown with success.

The following pulses are commonly grown in North East India—matikalai (urid), soya bean, arhar dal (pigeon pea), khesari dal, mattar dal (field pea), masur dal, moong dal, chana dal (gram, bhoot).

Pulses are leguminous crops and require a soil low an acidity, with plenty of phosphate and potash. Further information on the seed rates, manuring etc. of pulses is given in the above mentioned pamphlet.

Maize, millet, bajra etc. These crops are not extensively grown in Assam; maize and millet are however commonly grown in the Bengal Dooars and in the hill districts. They respond to heavy manuring and can be given up to 300 mds. cattle manure per acre. They also supply heavy fodder for cattle.

Vegetables. Most Tea Estates grow vegetables for the hospital and to supplement the diet of the labour force, and it is generally realised that there is little similarity between the requirements of the tea bush and that of vegetables and other food crops, in regard to their cultural requirements. Annual crops require good cultivation and generally heavy manuring. Moreover most vegetables grow best on soils which are low in acidity while tea thrives on an acid soil.

For all the crops with which we are here concerned, a dressing of lime at 10 to 15 mds. per acre will be advantageous. It is best applied in the form of slaked lime, as in this form it is more easily mixed with the soil and it has also a moderately toxic effect on many of the undesirable insects. When (slaked lime, the hydroxide of lime) is incorporated with the soil it gradually passes into the carbonate (chalk or limestone) forming a crumb like structure in the soil through which drainage is easily effected and aeration assured. In heavy soils this is particularly important and very greatly assists cultivation.

Lime whether present as the carbonate or hydroxide, lowers the acidity which in turn stimulates the nitrifying bacteria and renders nitrogen in organic compounds available to the plant. (Even a tea bush responds to

liming in the first year of application). Wherever the vegetable bari and whatever the soil, it is safe to add 10 mds. of limestone and 10 mds. of wood ash. The latter in addition to reducing the acidity supplies potash to the soil.

Wood Ash. The manufacture of wood ash in bulk is no easy matter owing to the fact that the light ash is liable to pass away with the hot air from the fire. To avoid this the dry material to be burnt, whether it be dried jungle or dried water hyacinth, should be piled 1 ft. high and covered with 3 to 6 inches of soil preferably on the site of the beds. In this way the jungle will burn entirely to ash in 2 or 3 days. While charcoal does no harm to a soil it is valueless as manure, and if the jungle is properly burnt practically no charcoal should remain.

Good ash contains over 10 per cent of potash and about 5 per cent of phosphate so that an application of 10 mds. represents 80 lbs. to 100 lbs. of potash which at the present market price would cost Rs. 35/-.

Phosphate. The only local supply of phosphate apart from the small quantity contained in wood ash is bones. This may be applied steamed to kill out anthrax etc. and crushed, or it may be applied burnt, and powdered by hand. The objection to burning the bone is that the nitrogen which it contains (3 per cent or 4 per cent) is lost and the phosphate is rendered rather less soluble, but in the absence of a crushing or grinding machine, burning is the only method available to us for reducing the bone to a state in which it can be mixed with the soil. Burnt bones if picked out from the fuel ash, contain about 40 per cent phosphate and if applied at 200 lbs. per acre give 80 lbs. of phosphate which would probably cost Rs. 40/- on the present market.

Bones—Wood Ash Mixture. To burn bones satisfactorily about thrice the weight of wood to bone is required. The resulting mixture of burnt bones and wood ash may be used for all leguminous plants at 200 lbs. to 400 lbs. per acre.

The Preparation of Organic Manures. Once again our close contact with the tea bush is liable to have warped

our ideas. Experiment has consistently shown that green manure can be applied to tea without its first being broken down into compost. For vegetables such a practice would be suicidal. White and red ants and crickets would flourish first on the jungle and then on the roots of the vegetables; moreover if such green material were mixed with the soil almost all the plants would show indications of nitrogen deficiency. One of the main objects of the market gardener is to break down the organic matter into a satisfactory composted material before applying it to the soil.

Much has been written about composts and many are the methods that may be followed with success. In general a compost heap made up of green jungle, cattle manure, and wood ash if available, must be large and high. High, so that the bulk of the material may be well compressed, and large because a high temperature must be developed to prevent the incursion of white ants and to kill the jungle seeds. Anything less than $12' \times 12' \times 8'$ (when first piled) is not likely to meet these requirements.

When the temperature begins to fall the pile should be turned and as far as possible turned inside out.

If it is desirable to speed up the reaction, sulphate of ammonia may be applied in concentrated solution—2 kerosene tins to the above heap.

Preparation of the Soil. One of the secrets of vegetable growing is deep cultivation, and the composted material, about 30-50 tons per acre and lime 15 cwt., should be dug into the soil so that they are well mixed with the top 12 inches. Finally the surface soil must be reduced to a fine mulch.

Application of Fertilizers. Tea is a perennial, it has the mechanism for picking up what it can when it can, but with most vegetables the time at which a soluble fertilizer is applied is most important.

Sulphate of ammonia should be applied when leaf growth is being made,—to "sags" for instance, just before the first leaves are ready for picking, but the

greatest care must be taken to see that it does not fall on the leaves.

Phosphates if applied to legumes should be dug into the beds before the seeds are sown, while potash if applied to root crops should be given when the roots start to swell.

Types of Vegetables. (a) Sag. Sag covers a variety of plants mostly of the *Amaranthus* species, the leaves and young green stems of which have a high vitamin content and are used as green vegetables.

Since the plants reach a yielding state in 20 to 40 days it might be well to order several varieties in the first sowing, omitting those varieties which prove unsuccessful, from later orders.

Sag varieties and Time of Sowing.

Palang Sag	..	June to October
Lal Sag ..	..	March to May, and Septr. to December
Pooye Sag (Creeper)		March to July

The two standard varieties, Palang Sag and Lal Sag may be planted out 12″ square, from the seed beds and later thinned to 24 inches square.

In harvesting Sag remember that the plant feeds by its leaves and that every leaf removed means so much less food for the plant. In this respect it is exactly like tea except that tea being a perennial takes longer to die and overplucking does not have the immediate fatal effect which it would have on a tender annual plant.

Pooyee Sag. A climbing plant, should be planted 2 ft. apart in rows 3 ft. apart. Some support is necessary for it to climb over. It grows luxuriantly and extensions can be put out from cuttings. A suitable manure for Sag is lime at 15 mds. per acre, followed by cattle manure at 20 to 40 tons per acre. Sulphate of ammonia may be given when the plants are 6 inches high at 1 oz. to every 3 plants, forked outside a 4″ diameter circle.

Brinjal. Varieties and time to sow.

Aman or Aus—September-October—Ready from February to May.

Kali or Benares—February-March—Ready from August to January.

The soil should be heavily manured and the plants will require earthing up to 18 inches high. It should not therefore be planted too close; 3 ft. × 3 ft. being usual, but this depends upon the variety. 1 lb. of cattle manure per plant should be given as surface dressing when the fruits set.

The plant is liable to damage by red ants, caterpillars and leaf curl.

Pumpkin, Lal Kumrah. This may be sown in position from March to June and again in October and November. The plants should be spaced 5 to 12 feet apart and allowed to creep over the ground. A rich light soil heavily manured with 40 tons or more of compost is required. Drainage is important and unless the soil is very light, the beds should be raised at least 1 ft. high.

Sweet Potato.—Planted April to June. Ready from September to December.

This vegetable is planted from cuttings about 3 ft. apart on shallow ridges. When the cuttings have grown sufficiently the stem should be pressed into the soil every few feet. Sweet potato requires the same manuring as pumpkin.

Okra, Lady's finger. Sow March to June. Ready from July to September.

Okra should be sown in position in rows 24 inches apart and 18″ apart in the rows. The plants should be tipped when 12″ high to make them bushy. Manuring is as for pumpkin, but 1 oz. of sulphate of ammonia given to every 3 plants when pods begin to appear.

Radish.—Sow during June. Ready from September to October.

The cultivation should be particularly deep and thorough, and the soil manured with 20 to 50 tons of humus or cattle manure.

Country Bean. Sow in position May to June. Ready from September to October.

There are several varieties of Indian bean, kholkhas, altapati, ghyia, makhum etc. All should be sown in

rows 6 to 8 inches apart and 5 feet between rows. Some support is necessary. Beans should be given bone-wood ash mixture at 200 lbs. per acre. Other manures may be unnecessary particularly if the land has been previously manured for some other crop just removed.

CHAPTER XII

PESTS AND BLIGHTS OF THE TEA PLANT

THE subject of pests and blights requires special study and cannot be dealt with in sufficient detail in a work like this. All that can be attempted here is a sketch of the general principles upon which the enemies of the tea plant may be most successfully met, and a few details regarding some of the most common and serious of those at present known. Any reader wishing to study this subject more fully is referred to the list of publications given at the end of this chapter.

CLASSES OF BLIGHTS

The blights of the tea plants are legion. They may be described as of three classes: (1) The attacks of minute animals or insects. (2) Vegetable parasites. (3) The violence of the elements, such as hailstorms, etc. It has become customary to class insect enemies as pests, and vegetable parasites, or fungi, as blights.

Although by far the largest number of our insect enemies have hitherto proved comparatively harmless, it is neither wise nor safe to assume that such enemies may be absolutely neglected. The proper attitude for the planter is to be on the alert and to make use of every possible protection and safeguard.

In 1938 certain gardens in South Cachar suffered very severe damage from the attack of a looper caterpillar —a pest which had never before in this district been considered serious. In fact many planters had never heard of the pest.

On one garden alone some hundreds of maunds of caterpillars were collected and burnt, and had not prompt and efficient measures been taken in this garden when the pest suddenly appeared in an intensive form, the results might have been disastrous for the district as a whole.

BLIGHTS FOLLOW AGRICULTURE

The experience is similar in every department of agriculture, that whenever any kind of cultivation is conducted on a large scale, the danger of injury or destruction from any particular blight becomes very largely increased, because, when a destructive insect lights upon an enormous field, containing an uninterrupted supply of the kind of food which exactly suits its constitution and general construction, the natural result is a rapid increase in its numbers and strength; this going on in an ever-increasing ratio until complete devastation and destruction of the crop supervenes; unless, meanwhile, some sort of check is placed upon it, or means devised whereby the invader can be destroyed or driven off.

LIABILITY OF TEA TO BLIGHTS

The tea plant is perhaps more liable to suffer from blight than most annual crops, because it is permanently in the ground. It is more liable than most fruit trees, because it is an evergreen, and gives ample opportunity for insects or fungi to deposit their eggs and spores wherever suitable, and so to ensure an ever-recurring and continually increasing brood or crop of the enemy upon the very field of attack.

GOVERNMENT ASSISTANCE

Neglect of such developments has in the past brought ruin to many industries. The importance of the matter has by now resulted in the Governments of practically all countries where agriculture is an important industry, establishing special departments and employing a staff of scientists whose duties are to study the nature of agricultural pests and blights, and to render every possible assistance to the cultivator in order to effect their extermination.

Previous to 1902, very little of this sort of work was done in India, and what little was done by Government for the tea industry had been spasmodic and superficial.

SCIENTIFIC EXPERTS

In 1901, however, a Scientific Officer was engaged by the Indian Tea Association, assisted by a grant from Government.

At the present time a staff of experts is engaged, not only in India, but also in Ceylon and Java, in studying the methods best suited to controlling the pests and blights of tea. The present situation in regard to the progress of this work is summed up in an article, written by the Chief Scientific Officer of the Indian Tea Association, in 1938, which appeared in the "Empire Journal of Experimental Agriculture".

The article is entitled "The Application of Science to Modern Tea Culture", and the following are the observations in it relevant to the progress of scientific investigations on pests and blights:—

"*Pests and diseases.*—In no part of tea culture has scientific investigation had a greater effect than in the recognition and control of pests and blights. Before scientific investigation came to tea, little or nothing was known concerning insect pests, except that they were doing damage. With a careful investigation of the life histories of the various pests, satisfactory control measures have been established for nearly all the more dangerous pests. The necessity for continuous attention to control measures is not yet adequately realized, so that every now and again an epidemic outbreak becomes serious for a while until control measures are once more in full operation.

The recognition that root disease often causes the death of bushes has resulted in the adoption of methods to prevent it from spreading, and whilst such diseases still occur they are no longer responsible for the very heavy loss of bushes that was formerly due to this cause. The study of disease organisms has greatly reduced the casualties.

Leaf diseases are controlled by systematic spraying and pruning. The disease that enters through pruning

cuts is still a difficult and as yet an unsolved problem, for whilst it is probably unnecessary and certainly impossible on a practical scale to treat pruning cuts in the ordinary course of annual light pruning (there are about 3,000 bushes to the acre), the heavier type of pruning, which is done at intervals of 10 to 15 years low down on the framework of the bush, does need attention. No entirely practical method for protecting the large cuts made at this operation has yet been found. The best remedy lies in the abolition of such forms of pruning, and this has already done a great deal towards maintaining the health of bushes. A problem that is still serious is how to treat rotting pruning cuts on old bushes; so far no satisfactory solution has been found."

It is of interest to observe that the following remarks were made in the earliest editions of this present treatise on tea:—

"It is the opinion of many planters that there should be an experimental station in each of the tea districts for practical investigation of the various problems affecting the industry, and for demonstrating the best methods of culture and manufacture. The Department has done good work, but there is still a vast field awaiting study and investigation."

The most recent development which has taken place in the Scientific Department of the Tea Association, consists in the appointment of advisory agricultural officers to the Dooars, Darjeeling and the Surma Valley. Though their work naturally embraces every department of the culture and manufacture of tea, it is intended that the study of measures for the protection of the tea bush against its insect and fungus enemies will occupy a prominent place in their investigations.

Insecticides and fungicides have been used for many years to combat pests and blights in tea, but choice is limited by the fact that, as the leaf is harvested weekly throughout the season there is danger, if certain types of spray fluid are used, of tainting or poisoning the made tea.

LIME-SULPHUR

Lime-sulphur is perhaps the most generally used spray fluid, and if efficiently employed proves very effective against many pests and blights.

Concentrated lime-sulphur solution can be obtained from various commercial concerns and is sold under a guarantee of certain strength.

The scale on which the strength of lime-sulphur solutions is measured, is known as the Baumé scale. The relationship of this scale to specific gravity is given in the table below :—

Gravity.	Degrees Baumé.	Gravity.	Degrees Baumé.
1·00	0·00	1·21	25·16
1·01	1·44	1·22	26·15
1·02	2·84	1·23	27·11
1·03	4·22	1·24	28·06
1·04	5·58	1·25	29·00
1·05	6·91	1·26	29·92
1·06	8·21	1·27	30·83
1·07	9·49	1·28	31·72
1·08	10·74	1·29	32·60
1·09	11·97	1·30	33·46
1·10	13·18	1·31	34·31
1·11	14·37	1·32	35·15
1·12	15·54	1·33	35·98
1·13	16·68	1·34	36·79
1·14	17·81	1·35	37·59
1·15	18·91	1·36	38·38
1·16	20·00	1·37	39·16
1·17	21·07	1·38	39·93
1·18	22·12	1·39	40·68
1·19	23·15	1·40	41·43
1·20	24·17	...	...

DRASTIC POLICY

The planter cannot be too earnestly cautioned against the fire and sword policy advocated by some people as a cure for almost everything. Cutting down and burning has been resorted to much too readily in the past. There may conceivably be times when extreme measures have to be undertaken, but it should be only with extreme caution, and after every moderate measure has failed.

SYMPATHY

When plants are suffering from any kind of blight they need sympathy and help. Anything which will tend to hearten and strengthen them will go a long way towards throwing off the enemy, or at least towards a complete recovery after the attack is over. On the other hand, the probablity is that severe threatment will only further weaken the bush and render it a more easy prey.

CLOSE PLUCKING

It used to be quite a common thing for a planter, when blight appeared, to give orders to pluck as cleanly as possible leaving not a vestige of new growth, when the probablity was that the extra labour and money would have been a hundred times better employed in measures for improving the fertility of the soil and rendering the bushes more capable of resisting disease.

In the same way, cutting down and burning was sometimes adopted without the least benefit; the new shoots were found to be immediately attacked by insects from the neighbourhood as before, and the plants being in a weaker state suffered more than ever.

Even at the present time, the cynic is not wanting, who is apt to declare that the worst enemy of the tea bush is the tea planter, but this is, at any rate nowadays, an unjust accusation.

There is probably no agricultural industry in which there is a more earnest desire on the part of the producer to consider the health of the plant. It is true however that little progress has been made in the development of suppressive measures against certain enemies of the tea bush, and equally true that such effective measures as are known, are often neglected on the plea of excessive cost, or lack of the necessary labour to carry out the necessary operations. The tea industry in North-East India has, it is true, never been menaced by a pest such as the "green bug" which ruined the coffee industry in Ceylon many years ago, but there are diseases and pests which take an annual toll of crop much greater

than is realized. Of these red-spider is probably the chief, while the tea-mosquito bug and various caterpillar pests, black rot, various root diseases, and blister blight all have serious effect in various localities and in different years.

SEASONS FOR PESTS

Most pests have their season and disappear in a natural way when their term is over; the eggs of the insects are however left somewhere near, possibly on the bush itself inside the bark or stems, or on the surface of the older leaves, ready to be developed when the suitable season comes round again.

NATURAL CHECKS

Were it not for the natural checks to which most insect pests are subject, the tea plant would soon be devoured from off the face of the earth. A change of weather may make the conditions of life impossible for any particular insect. A change of season has in some cases the same effect, so that we know roughly when to expect the appearance of certain pests, such as red spider, and also when climatic or other conditions will reduce the attack to insignificant proportions: a few of these mites may indeed be seen at other times of the years, but seldom to any harmful extent.

INSECT ENEMIES

Perhaps the most important check to most pests is that which is brought about by natural enemies. As has been already pointed out, all insect pests spread and multiply very rapidly when conditions are favourable to their development; on the other hand, however, there are insects of a carnivorous and some of a parasitic nature which prey upon these, and when they also get a start, the career of the first may be cut short, or at least be very greatly restricted.

Curiously enough, some of these parasites deposit their eggs in the very abdomen of their victims, so that the insects themselves are thus made to foster the means of their own eventual destruction.

It is probable that for some such reason as those mentioned above, the mosquito blight very often receives a severe check or even disappears entirely for a time, in a most astonishing and unexpected manner.

RED SPIDER

One of the oldest enemies of the tea plant is the red spider (*Tetranychus bioculatus*). Many remedies for this have been tried, including every known insecticide. Some of these are reported to have a very marked effect upon the blight for a time, but the only one which has yet been found to work effectively and at the same time to be economically practical is lime-sulphur solution. Planters have also tried pulling off the affected leaves, burning prunings, heavy pruning, light pruning, late pruning, and thinning out. The only effect which late pruning has, is that the blight may appear a little later, but its results may be just as serious.

The following notes represent results of observations, experiments and general experience of planters in North-East India on the effect of various control measures against the attack of red spider.

TIME OF APPEARANCE——HEAVY RAIN

The time of appearance of red spider on mature tea is when the leaves of the first flush begin to mature and harden, usually about the end of April. A red tinge first appears on the older leaves, and it almost appears as if the eggs were within the sap itself, and that the mites make their way to the surface immediately on being hatched. Very soon the old leaves are all covered with minute red animals or insects. They can with difficulty be seen by the naked eye, running about with great energy and extracting the juice of the leaf, which in

consequence, gradually dries up and becomes brown before eventually falling off the bush. Some people fancy that heavy rain washes off the red spider. There is reason to doubt this, because at times very heavy showers of rain have fallen early in May, when the blight has been at its liveliest stage, and whenever the rain had cleared away the insects of mites seemed even more active than before.

When the attack has become severe and the older leaves are all sucked dry, the mites attack the new growth of the second flesh; the weaker bushes soon give up the hopeless struggle, and for a time all growth on these is almost completely stopped.

TIME OF DISAPPEARANCE

About the middle of June or at the time of the advent of the monsoon rains, the red spider generally diminishes or disappears, but the mite is actually present on the bush in small numbers and in all stages of development, from egg to adult, all the year round.

PERMANENT EFFECTS

The permanent evil effects of this pest are perhaps more serious than of any other to which the tea plant has hitherto been subject on any large scale. The bushes severely attacked, especially if already weak through other causes, become more and more enfeebled after each attack; they gradually get into a sort of anæmic state, and the stems and twigs become white with parasitic growths.

LIME-SULPHUR SPRAYING

There are various preparations in use for checking or mitigating the effects of red spider. The most effective yet known is lime-sulphur spray. The best time for application is at the first sign of attack in April or May. Spraying after pruning in the cold weather has

been found to be ineffective against subsequent red spider attack, on mature tea.

Lime sulphur may be made on the garden, or bought from various commercial concerns in very concentrated form. This solution is normally sold at a concentration denoted as 30° Baumé, being the gravity of the solution as measured by the Baumé scale. An effective dilution of this solution is 1 part to 36 parts water.

The cost of the concentrate is about Re. 1-4 per gallon to which must be added freight. Often it is cheaper to make less concentrated solution locally, provided it is made properly. A concentrate of 20° to 25° Baumé can be made by boiling up 50 lb. good quick-lime with 50 gallons water and adding 100 lbs. of sulphur (ground to pass at least a 60-mesh sieve). Boiling should take not longer than 45 minutes from the time all the sulphur has been added. The clear golden brown solution is drawn off when cool and can be diluted in the ratio of 1 part solution to 20 parts water. About 200 gallons of diluted solution are required for effective spraying of mature tea.

EFFICIENT SPRAYING NECESSARY

One of the reasons for apparent failure of lime-sulphur spraying to check red spider attack is that the spraying has not been done effectively. In order to cover a large area of ground quickly, the spraying men merely direct the spray over the surface of the bushes, leaving the sides and leaves below the surface unsprayed. Thus a large area of leaf, and often that area which carries most red spider, is left untouched. It is far better to concentrate upon the worst attacked areas in the garden and to spray these thoroughly, than to try to cover a large area rapidly. Moreover, a weak solution sprayed really thoroughly is far more effective than a stronger solution applied inefficiently. The cost of spray fluid per acre using 1 to 36 dilution of 30° to 32° Baumé concentrate is not less than Rs. 9 per acre, if 200 gallons of solution (containing 6 gallons of concentrate) are

applied. To this must be added labour costs, depreciation costs on machinery, etc., bringing the cost up to Rs. 15 or more per acre. A severe attack of red spider, however, may easily cause a loss in actual crop of considerably more value than Rs. 15 per acre over a considerable area, while permanent damage, which is impossible to estimate in rupees, may also result.

SULPHUR DUSTING

A very popular method of treating red spider both on nurseries and planted tea, is dusting the plants with finely powdered sulphur. The usual method is to shake muslin bags containing the sulphur over the bushes, and the work should be done early in the morning when there is dew on the leaves. For this treatment to be effective, fine weather is considered necessary, since the full effect is not obtained unless the sulphur remains on the leaf, without being washed off, for two or three days. Possibly the good effect of sulphur dusting is due to the action of strong sunshine or intense reflected heat which tends to convert the sulphur into some vaporized form.

OTHER SPRAY FLUIDS

Many kinds of spray fluids have been tried against red spider, and some are as equally effective as lime-sulphur solution, but their cost is often prohibitive.

EFFECT OF PRUNING ON RED SPIDER

Method and time of pruning influence red spider attack considerably. Earliest pruned sections, which have had time to accumulate a considerable amount of mature leaf and *banjhi* growth by April or May (the time when red spider attack is expected), are more liable to attack than late pruned tea with little but immature leaf on it. What is a far more important factor in pruning, however, is the degree of cleaning out during pruning. Unpruned or skiffed tea, or tea which is top

pruned without cleaning out *banjhi* growth, is very much more liable to attack from red spider than tea which is cut back, or top pruned and properly cleaned out.

DEFOLIATION

In some districts, complete defoliation of pruned bushes is resorted to as a protection against red spider attack, and certainly a bush completely deprived of leaves at the time of pruning is much less liable to attack than one which is pruned leaving a lot of *banjhi* and old leaf on the bush. Defoliation is however a practice which is certainly inadvisable on young or weakly tea, which is likely to be low in reserves and needs all the leaf it can retain after pruning to keep it alive.

A plan which seems to be effective especially on gardens which cannot clean prune the whole area, is to clean prune or defoliate about half a dozen rows of bushes alongside every main road in the garden. Red spider frequently develops first on the dust covered bushes alongside a road, and defoliation of these bushes often has the effect of preventing the spread of red spider from roadside bushes.

JAT

In general, the dark leaf *jats* are considered to be more susceptible to red spider attack than light leaf bushes, but this is only a generalization, and does not imply that because a bush is dark-leaved it will necessarily be more liable to red spider than a light-leaf bush.

EFFECT OF OTHER CULTURAL FACTORS

Good drainage, clean cultivation, adequate manuring (more especially with manures of the efficient "quick acting" variety), moderate shade, and in fact all operations which encourage health and vigour in the tea bush, have the effect of reducing the harmful effects of red spider attack.

THE TEA MOSQUITO BUG

Only second in importance to red spider, among the pests of the tea plant, is the tea mosquito bug (*Helopeltis theivora*). This pest is most prevalent in the Dooars, Terai and the Surma Valley, but can also cause serious damage to tea on the lower elevations in Darjeeling, and in certain districts in Assam—Nowgong for instance. It does not now however appear to cause such serious damage as it did formerly.

It is recorded that at one time the ravages of the pest threatened to destroy the industry, and indeed it did bring about the ruin of several companies in the Darjeeling Terai about the years 1888-90.

Its operations are mysterious, and its coming and going sometimes quite incomprehensible, although the time when it does greatest damage is usually after the growing season is half over.

LIFE HISTORY AND METHOD OF ATTACK

The fact that the mosquito bug is a winged insect renders it somewhat difficult to deal with in its mature stage. The life history of this insect was recorded many years ago by C. B. Antram, for the Scientific Department, but even yet no reliable or complete cure for it has been discovered.

The following extract from "Factors affecting the Control of the Tea Mosquito Bug", by E. A. Andrews, at one time Entomologist to the Indian Tea Association, describes the changes undergone by the pest in its life cycle, and the methods it employs in feeding and laying its eggs on the tea bush :—

"The insect, in common with most insects, commences life by emergence from an egg, laid by the female parent. The position in which the eggs are laid is of considerable importance. The egg is a minute white sausage-shaped body about 1/32nd of an inch in length with blunt rounded ends, and with two fine white hairs

of unequal length attached near one end. It is thrust into the plant tissues with its long axis perpendicular to the surface, and is completely embedded, except for the two white hairs, which project from the surface and make it possible to ascertain the position of an egg from without. By being thus embedded in the plant tissues the eggs are completely protected from the action of insecticides or ovicides, the more particularly so since the projecting hairs, by capillary attraction, tend to withdraw drops of liquid from contact with the actual surface of the egg. The positions in which the eggs are laid are numerous and varied. They may be placed in any position in the green stem, from the red wood upwards, they are laid in the petioles and mid-rib of the leaves, in axillary buds at the base of the leaf stalks, in the broken ends of plucked shoots, and in scars where leaves have fallen off. Any position on the bush in fact, where the tissues are sufficiently soft for the insect to insert its ovipositor, and where there is sufficient depth of tissue to afford adequate protection to the eggs, may be chosen by the female. The importance of this will be seen when the influence exerted on control by the operations of plucking and pruning are discussed. The insect emerges from the egg as a small, active insect capable of feeding on, and doing damage to the plant from the first. It travels straight up the shoot until it reaches leaf young and tender enough to permit of the insertion of its proboscis, and commences to feed. From then on, until attaining maturity, the insect continues a career of active destruction, undergoing, during that period, four moults, after each of which though retaining in the main its original form, it becomes larger and more robust, and capable of doing more harm in a given time. When first born, the insect is without either the spine on the back, or the wings. The former is first acquired, though in an incomplete form, at the first moult; the latter first appear, though not in a functional condition, at the second moult, and after each moult these organs become more fully developed. At the end of this period the insect undergoes a fifth moult, when the fully winged adult stage is reached

which, in addition to doing damage by feeding on the plant, is capable of reproducing its kind. Thus the whole of the life cycle of the insect is completed on the tea bush, and, although the insect is known to feed on other plants, their presence is not necessary for the completion of its life cycle, nor does the insect pass through any stage of its life history in water, as many have supposed because it has been unfortunately misnamed the "tea mosquito" instead of the "tea bug".

MOSQUITO MARKS—SEVERE ATTACKS—USUAL TIME OF BLIGHT

Wherever the proboscis of the bug has been inserted into the young tissue of the tea plants a small round patch of dead tissue is the result. As the insects become more numerous, the number of these patches increases, until the young leaves all assume a blackened appearance. When conditions are favourable for the pest and the attack has become a very severe one, the overcrowded insects seize upon any young buds which manage to make an appearance, and soon the whole block of tea presents a truly blighted look, the whole of the bushes showing upon their surface nothing but a series of curled and blackened ends turned up to the sky, all new growth being stopped. This condition of things has sometimes obtained over quite a large area on gardens in the Terai, even as early in the season as the end of July, the very time when growth should be most vigorous and luxuriant. In ordinary circumstances, however, this blight is worst from September or the beginning of October, till the end of the season. The mosquito sometimes appears quite early in the season, and may even spread over a large area, but usually disappears again in an unaccountable manner.

Attempts have been made for many years to obtain some correlation between the severity of the attack of the mosquito bug, and various cultural, climatic and soil factors, with a view to complete control of the pest.

CLIMATE AND MOSQUITO BLIGHT

A cool wet spring is generally considered to be conducive to an early attack of the blight, but if good growing weather follows early rain, the spring attack of the bug seldom reaches serious proportions. Many planters consider that early drought is associated with severe attack of mosquito bug later in the season, but most are agreed that attack during the rains is most favoured by continuous dull weather, such as is often experienced in the Dooars in the rainy season. It seems to be more a question of lack of sunshine than of excessive rainfall, though a poorly drained garden is likely to suffer badly during a season of heavy rainfall especially if much of the rain is concentrated over a fairly short period.

Generally speaking any climatic condition which causes a very marked slowing up of growth appears to favour attack of *Helopeltis*.

CULTIVATION

Most planters agree that clean cultivation lessens the liability to attack by mosquito bug, but many consider that excessive cultivation—trenching, deep hoeing and much rains cultivation—may have a bad effect.

PRUNING

It is very generally agreed that heavy pruning increases liability to attack. Opinions on light pruning vary however, some holding that unpruned tea is more liable to attack than pruned, others the opposite, while others again have observed pruned and unpruned to be equally liable. As regards clean pruning, general opinion in the Dooars is that too severe clean pruning increases liability to mosquito attack.

PLUCKING

Opinions are divided on the effect of plucking, one view being that lenient plucking, which increases the health of a bush, reduces damage from the mosquito

bug; the other view being that close plucking at regular intervals keeps off the attack. These views are not however opposed; if tea is weakly, lenient plucking assisted by adequate manuring will improve its vigour, and when in a sufficiently strong condition, the bush is able to stand close and regular plucking, which reduces mosquito attack on vigorous tea by reducing the number of succulent young shoots left on the bush.

SHADE

Most opinions agree on the bad effect of heavy shade, though light shade is generally held not to be harmful but rather the reverse.

Heavy growth of green crop, e.g., boga medeloa or arhar left unlopped, is undoubtedly a factor in encouraging mosquito blight.

SPRAYING

No insecticide was found to be effective until experiments on the use of DDT were conducted by the Research Stations of North-East India and South India. These experiments have proved the efficacy of DDT, either as a water-miscible emulsion or as a dust and memoranda have been published on the subject of control of *Helopeltis* by DDT spraying.

PARASITES OF THE TEA MOSQUITO BUG

A certain number of parasites and predators on the tea mosquito bug have been found, but no particular parasite is known which is in sufficient numbers to cause any marked reduction in the incidence of the pest.

CATCHING OF MOSQUITO BUGS

Certain districts are more liable than others to attacks from mosquito, and certain blocks of an estate seem to get it more readily than others. If these blocks are watched and treated immediately the pest appears, the attack may be kept to some extent in check, or its

results somewhat minimized. Catching the insects by hand and destroying them seems a very primitive way of dealing with tiny flies which can scarcely be seen; but some planters are of opinion that in the early stages of a visitation a great deal of good may be done in this way. Probably, where labour is plentiful, the children can be so employed with some profit, but in any case it can only be a palliative, and cannot be looked upon even as a remedy, much less as a complete cure.

An interesting suggestion has been made that possibly this blight might be checked by the application of suitable chemical manure to the roots of the bushes. This is a method which has been successful in some other forms of agriculture; but has not yet proved successful in dealing with tea blights. For a time it was supposed that a liberal application of potash to the soil would banish the mosquito, but the experiments in this direction have not thus far been encouraging.

CLOSE PLUCKING

Whenever mosquito blight appears, close plucking may be resorted to. This will do very little harm to vigorous bushes, as it usually comes after the middle of the growing season, and the bushes will have already made sufficient growth to prune upon. Some planters do not like to see the coolies bring in leaves which have been somewhat damaged by mosquito. Such leaves make very poor tea, but it is very desirable that they should be plucked off the bushes, because their stalks contain eggs of the insects, and if the bushes can be plucked close and clean, there is some hope of getting a fairly good flush afterwards.

BADLY DAMAGED LEAF

Leaf which has been much damaged by mosquito becomes quite black and crisp, almost exactly like manufactured tea in appearance, but it is of practically no value, because its sap has all been extracted.

Effect of Green Fly Blight

GREEN-FLY

The tea green-fly (*Empoasca flavescens*), although really a pest, is often regarded as the tea-maker's friend. It is the only blight which apparently does not injure the quality of leaf for manufacture; on the contrary, a visitation of this insect is regarded as a sure promise of fine flavoury teas; provided always that the attack is not so severe as to stop growth altogether; in which case it is indeed a calamity. Green-fly may be seen upon various kinds of shrubs besides tea. Its effect appears on tea usually about the time when the second flush begins to grow, and may remain a month or so.

Andrews (I. T. A. Quarterly Journal, 1927) states ". . . .the generally accepted idea that green-fly causes stunting of the bush still remains unproven. Attempts have been made, each season, to produce the stunting effect on tea bushes kept in cages, by steadily introducing numbers of the insects onto them, but without any apparent result. This confirms the observations of Watt and Wright, in so far as one negative result can confirm another, and adds force to the possibility of the appearance of the stunted effect, at the time when green-fly reaches its most active condition, being only a coincidence.

Further weight is added to these results by the fact that, whereas the period June to July is usually regarded as the 'green-fly season', and is, as a matter of fact, a period at which green-fly has reached its maximum activity, yet, although the 'green-fly effect' goes off in August and September, the activity of the insects continues undiminished and it is not until October that their rate of development shows any definite sign of slowing down. This is clearly shown by the breeding records.

The evidence so far obtained in this connection, therefore, would appear to sway the balance against the idea that green-fly produces stunting of the flush of the bush."

The photograph opposite shows the effects generally associated with green-fly blight. The shoot, marked No. 1, is the natural size; the other shoots are of the same

class at different stages of blight, No. 5 being completely blighted.

THRIPS

Thrips is a pest, common in the Darjeeling district, whose ravages are hardly distinguishable from the effects of green-fly. The leaves affected assume the same stunted appearance, and there is a similar shortage of crop; but there is this difference, that the action of thrips does not effect any improvement in quality: so that this pest has no redeeming feature. Actually the name thrips is a "popular" one applied to a group of insects known as *Thysanoptera*, the name indicating that they have fringed wings. The thrips as encountered on tea bushes is a tiny insect shaped like a torpedo; the form of which enables it to burrow between the unopened embryo leaves of a young leaf bud. In this situation it is secure from the influence of any insecticide which may be applied to the bush. Spraying with a strong solution of starch, or with rosin solution, was at one time expected to prove effective, by sealing up the leaves and so causing the mites to die of suffocation; but in practice the sealing film soon becomes broken under the influence of growth of the bud, and as a result there are always some survivals.

The damage is done by this pest while the leaves are in the embryo stage, so that when they develop and open out they are stunted in size, and a portion of each leaf, especially round the edges, is found to be of hard woody fibre without sap, which is the chief characteristic of leaves affected by this pest. On estates at high altitudes this is by far the worst insect enemy with which tea has to contend.

Spraying with various insecticides such as Insectox, Clensel, etc., kills the insects, but unless other measures are taken to increase the vigour of the bushes, the latter cannot be taken advantage of the destruction of he pest and no great benefit results from spraying.

OTHER LEAF-EATING PESTS

Other pests which do damage by eating or puncturing the tea leaf and succulent stems are the looper caterpillar, lobster caterpillar, bunch (or cluster) caterpillar, sandwich caterpillar, faggot and bag worms, leaf rollers, red slug, orange beetle, tea aphis and others. As a general rule these pests do minor damage, but attacks in some cases at any rate, may if unchecked assume alarming proportions and it is always well to be on the watch for them.

FORKING ROUND THE BUSH

With some pests, such as the caterpillar pests for instance, there is a certain value in "kurpying", or "thullying" in the cold weather, and collecting at this time all chrysalides found in the soil round the bush. Later, when the chrysalides of the various insect pests hatch out it may be necessary to send gangs round to catch them in the winged stage, and again in the larval stage after hatching out from their eggs. Bunch or cluster caterpillars are easily dealt with in the larval stage as the cluster of greenish brown caterpillars on the frame of the bush is conspicuous and the droppings on the soil are a tell-tale indication of the infested bush.

CATCHING AND COLLECTING

Systematic searching for pests by specially detailed gangs of children is a wise precaution, especially in the early part of the year, in districts or gardens known to be liable to pests of this nature. Generally speaking, except possibly for tea aphis, which in any case does little harm to mature tea, spraying is not regarded as effective against the pests mentioned above.

There are many pests which do damage to the roots or the wood of the tea bush or young tea plant among which the most important are white ants, crickets, bark eating borers and caterpillars, red borers, cock-chafers, and scale insects.

WHITE ANTS

Normally in North-East India, white ants (or termites) do not attack live wood, though there are species, all of the genus *Calotermes*, which feed on living and apparently healthy tissues, and have been reported to do a great deal of damage to tea in Ceylon.

It is certain that much of the damage attributed to white ants in North-East India is due to previous damage to the tea bush, resulting in death of some of its tissue, upon which the white ants feed. Dead snags of wood left after pruning, especially if low down in the frame of the bush, damage by cultivation implements, especially the hand fork, by animals such as cows and goats, all tend to increase the occurrence of white ants in a section, by providing them with a continual supply of dead wood to feed on. The only effective way of dealing with white ants is to find their nest and dig out the queen ant, a large white grub often two or three inches long and an inch in diameter, altogether a loathsome looking object.

Where a nest has been discovered and excavated, a liberal application of sulphur is recommended, to increase the acidity of the soil, which is generally found to be alkaline or very low in acidity where white ants have operated.

BARK-EATING BORERS AND CATERPILLARS

There are two species of bark-eating borer which do considerable damage to the bark of the tea bush, and in addition bore into the stem for an inch or so, usually at a pruning mark or at a point where a dead snag has been broken off.

The borer when feeding on the bark, builds raised cases or "runs" made of its own excreta spun together into a brown web with fine silk-like threads. Old hide-bound bushes appear to be most susceptible to attack especially if full of snags and knots. The bark-eating caterpillars are similar to the borers, but do not bore into the stem. The caterpillars and borers are about $\frac{1}{2}$ to $\frac{3}{4}$

inch long, except the Large Bark-eating Borer which is nearly $1\frac{1}{2}$ inches in length.

The best time to deal with these pests is at the time of pruning, when all caterpillars and borers should as far as possible be collected and destroyed. The borers are not easy to catch as they retreat to their holes when disturbed. These holes should be located and treated with a drop or two of kerosene or crude oil to destroy any borers which have retreated into them.

As these pests do not feed on soft bark, a cold weather application of strong lime sulphur or caustic wash is of assistance in controlling their depredations. This treatment is also effective against scale insects, and has been successfully employed on Darjeeling gardens.

RED BORER

This pest is quite common on tea in all parts of North-East India but has never done widespread damage. Its presence is indicated by the withering of the leaves on a branch, and by the light brown excreta, or frass, on the soil directly below the place where the borer has entered the stem.

On cutting open an affected branch it is found to be merely a tube, the inside having been tunnelled out by the borer. The only treatment is removal of the affected branch and cutting out and killing the borer, which is a reddish coloured grub up to an inch in length.

COCKCHAFERS

This pest, the grub of which is known as the *Kumli Kira* in Darjeeling, is responsible for considerable damage to nurseries. It is introduced by the use of fresh cattle manure which has not fermented sufficiently to destroy the larvæ and eggs of such pests which are common in fresh manure.

TEA SEED BUG

The tea seed bug (*Poecilocoris latus*) is a brightly coloured bug which is commonly found on tea seed trees

and sucks the juice of the tea seed, causing the well-known "starring" effect on the cotyledon of the seed.

The eggs of the bug are pearly white and about $\frac{1}{4}$th inch in diameter, and are laid in clusters of 10 to 15 eggs on the leaf of the tree. They turn brown before hatching and newly hatched insect starts feeding a few hours after emergence. It passes through five moults becoming an adult after the fifth moult. The immature and adult insects are brightly marked with red, yellow and black, with a metallic blue in addition in the case of the adult. The full grown bug is up to $\frac{3}{4}$ inch in length.

Collecting and destroying the catch is the only satisfactory treatment, though good results are reported by Andrews from the use of Cyanogas dusted on the trees at the rate of two-thirds of an ounce per tree, costing about Rs. 30 per acre of seed garden so treated.

PESTS OF SHADE TREES AND GREEN CROPS

Reference has been made in the chapter on Shade Trees and Green Manures to various insect pests of shade trees, but little is known at present regarding the treatment of most of them, except that spraying is usually impracticable, and catching, in the grub or chrysalis stage, may be effective.

FUNGUS DISEASES

Less than 30 years ago only about a dozen fungus diseases of the tea bush were definitely identified; at the present time nearly two hundred are known, of which about half are known to occur on tea in India, though comparatively few of these cause serious damage.

Fungi belong to the plant kingdom, but differ from green plants in that the latter need light for their development, whereas fungi are unable to use light and do not require the complicated structures characteristic of green plants, in order to build up their food from simple substances.

Fungi feed on complex organic substances which they break down, using the energy thus set free. They

propagate by means of spores, minute simple structures which are produced in enormous numbers, and are generally very delicate. For this reason they are usually protected by the parent fungus and set free only when conditions are favourable.

Many fungi live on dead organic matter, *e.g.*, dead snags of wood on the frames of tea bushes, and pieces of dead wood in the soil; others however feed on living tissue.

The fungus diseases of the tea plant may conveniently be divided into leaf, stem and root diseases, though the division is not by any means a definite one: some diseases attack both leaf and stem, others both stem and root.

LEAF DISEASES

Among the leaf diseases of tea the most important are Blister blight, Brown, Grey and Copper blights, Black rot, Thread blight and Red rust. All of these however, except Copper blight, may also attack the young green stems.

BLISTER BLIGHT

Blister blight (*Exobasidium vexans*) is first seen in the form of round spots on the young succulent leaf. These spots are translucent and are yellow or pink seen from the upper surface of the leaf. Later the spots enlarge and become white or pinkish on the under side, and appear from this side like convex warts. At a further stage these warts shrink and become brown or black spots which dry up. Finally they usually crack and fall out leaving a hole as if an insect had eaten out the leaf.

This disease is common on high elevation tea, as for example in Darjeeling, but is also found in plains gardens. In severe attacks the green stems of the plants are affected and much damage may be done to cut back tea especially if attacked early in the season, before the new growth has hardened up and so become immune.

Species of *Exobasidium* have been traced to rhododendron forests in Sikkim, and also occur on *Camellia* species growing wild in the hills bordering Assam. It is possible that the particular species known as blister blight on tea may have originated from these sources, the spores having been carried by the wind.

The disease is favoured by cool wet spells of weather, and is particularly susceptible to temperature variations. A temperature of 80 to 90°F. is sufficient to kill the fungus, and in the plains it can survive during the rains only in cool shady places.

If the disease has been neglected until it is widespread on a garden, it is hopeless to attempt to eradicate it until climatic conditions unfavourable to the disease supervene. At best, cut back tea and nurseries can be protected by spraying with Perenox. This treatment is also effective in dealing with the first signs of outbreak on those areas which by their situation are particularly liable. Removal and burning of old diseased leaves in the cold weather at pruning time has also been advised.

BLACK ROT

This disease gets its name from the fact that badly attacked leaves turn black and sodden in wet weather. The dry leaves have a grey-brown mottled appearance and cling together with light brown strands of the fungus. The disease occurs on patches of the bush, the rest of the bush being apparently free from the blight. The disease may spread with great rapidity in warm wet dull weather, vigorous bushes being just as severely attacked as weak ones.

Originally it was considered that the best means of treating this disease was to clean prune in the cold weather, burn the prunings, and spray the bushes with lime sulphur. This treatment was apparently successful in many cases, but there were many cases which failed to respond to cold-weather treatment and it has been found that treatment of the disease during its active

period—in the rains—is essential to prevent it from doing serious damage.

At present there is little evidence that variations in manuring, plucking, cultivation or other cultural treatments are likely to have any marked effect on incidence of the disease, but experiments and practical experience alike show that the disease can be controlled by efficient spraying, during the growing season, of affected bushes. A one per cent Burgundy mixture containing rosin adhesive or ½% Perenox is found to be most satisfactory. A special gang should go round affected areas after the plucking women have been through, and spray those bushes which have been marked by the plucking sirdar, or someone else specially told off for the job.

Spraying should not of course be done on areas which are to be plucked shortly, as the leaf will then carry the dried constituents of the spray fluid and the resulting teas are very liable to be adversely affected.

THREAD BLIGHT

This is a fungus similar to black rot but does not appear to cause such serious damage. Thread blight forms very characteristic white thread-like strands over the stems and under surfaces of the leaves, which in severe attacks turn brown or grey, and die, much as they do in the case of black rot.

As with black rot, thread blight thrives best in shady damp situations, *kunchis* and jungle edges, where it is doubtless introduced from jungle trees, on which it can be seen at any time of the year.

Treatments which have been advised are (*a*) to remove excessive shade, cut back jungle edges, and improve the drainage, (*b*) clean prune and burn the prunings, and (*c*) spray in the cold weather with lime sulphur. It is possible however that treatment similar to that now found effective against black rot may prove the most effective against thread blight.

The other leaf diseases such as brown and grey blights and copper blight seldom do serious harm, though

they are commonly seen, especially at the end of the season, on good tea as well as poor tea, which has been closely plucked. Healthy tea certainly suffers little or not at all from these blights, and where they are very prevalent the indications generally are that cultural conditions, i.e., manuring or plucking, are not as they should be.

STEM DISEASES

Red rust is a common disease, especially of young tea, and is characterised by patches on the stems which are an orange colour at certain stages, and have a dark steely appearance at others. Too severe pruning of young plants, and weakening by red spider attack, drought, waterlogging, etc., appear to favour the disease. Spraying with lime sulphur, or preferably Perenox or Burgundy mixture, and rest from plucking, assist bushes to recover from this disease.

NECTRIA

Tea attacked by this disease becomes sickly and moribund, but does not usually die out. The branches die back and any new shoots formed are thin and miserable ones. In general appearance the attack is similar to that of bad Red rust. Callosities may very occasionally be formed on the branches, and red or pink cushions of the fruit bodies can be seen at certain stages on the diseased stems. The disease is alleviated by spraying, removal of badly affected branches at pruning time, and by general methods, such as manuring and light plucking, which improve the health of the bush.

OTHER TYPES OF BRANCH CANKER

In addition to the above there are other fungi such as *Macrophoma theicola* and *Corticium salmonicolor*, which cause the branches of the tea bush to die back. Treatment

is as recommended above but it is naturally most desirable to avoid the occurrence of such diseases as far as humanly possible. There is no doubt that the practice of cutting tea back in the rains renders the bush more liable to these attacks of stem disease. This is discussed more fully in the chapter on pruning.

ROOT DISEASES

It is necessary to distinguish between those root diseases which are directly caused by some parasitic fungus, and those in which the fungus is merely a secondary factor. For example, when a bush dies, or becomes so decayed and moribund that it ceases to be of any use as a leaf producer, the trouble may be a specific parasitic fungus which attacked the bush when it was perfectly healthy and caused its death. On the other hand, a bush which has been badly treated in some way, e.g., starved, or over plucked, may become so weak that the presence on its roots of a fungus, harmless to a healthy bush, may be sufficient to cause its final demise. Such a bush when dug up with the fungus on its roots or frame, is put down as having died from that particular fungus whereas the true cause is quite other than fungus attack.

A few of the root diseases in which the fungus itself is the primary cause of the trouble are described very briefly.

1. Charcoal Stump Rot (*Ustulina zonata*) occurs on all types of soil, more especially on lighter ones. Bushes usually look sickly for some weeks before death, which occurs suddenly, the leaves wilting and turning brown in a day or so. The fungus grows between the bark and the wood, and if some bark is stripped off round the collar or roots, white fan-shapped patches will be seen. Sometimes on the outside of the bark, black crusts of fungus may also be seen.

2. Brown Root Rot (*Fomes lamaoensis*). Bushes may suffer for many months from this disease, though when they die, they pass out suddenly, often two or three adjoining ones at the same time. The diseased

roots are found to be encrusted with sand or soil, held together by a felt-like mass of brown fungus. On cutting open the wood it is seen to be marked with thin brown lines.

3. Black Root Rot (*Rosellinia arcuata*), Red Root Rot (*Poria hypolateritia*) and a few others of rarer occurrence, are primary diseases.

Among secondary diseases are Violet Root Rot (*Sphaerostible repens*), *Thyridaria tarda*, both very common in North-East India; Jew's ear fungus (*Auricularia auricula judae*), certain species of *Poria*, and many others.

PREVENTION AND TREATMENT

The measures for treatment and prevention of both the primary and secondary root diseases are naturally very different in many important respects from those advised years ago, before the true nature of these diseases was understood. Isolation trenches and the liberal application of lime are no longer advised. The only reliable treatment is the removal of all diseased bushes, together with all dead wood in the soil in the neighbourhood.

In addition, care should be taken in removing shade and other trees from a section of tea, to ensure that no dead wood is left to form a focus of infection in the soil.

In all work of this nature the importance of supervision and of having the work carried out thoroughly, cannot be over-emphasised.

In the treatment of secondary root diseases, the main point to remember is that the disease is secondary and that (apart from the obvious course of removing dead bushes, etc., as in the case of attacks from primary diseases), the essential thing is to seek out the cause of the trouble, and set that right. It may be waterlogging through bad drainage, starvation, bad soil condition through the use of the wrong type of manure or faulty cultivation methods, or mistakes in pruning or plucking:

but whatever is the cause, no cure can be effected till the underlying cause of the disease attack is discovered and corrected.

HAIL DAMAGE

Most districts in North-East India are liable to damage from hail-storms during April and May particularly. Some districts, and often certain gardens in a district, are more liable than others, and the damage, particularly to unshaded nurseries, young tea and cut back tea, may be extremely alarming at times.

Although hail is not usually reckoned as a blight, yet it is certainly very blighting in its effects, especially when it falls over a large area, and the question of how to treat the bushes afterwards is sometimes of very great importance.

CAUSES OF HAIL

The usual time for a serious fall of hail is at the end of April, or during the month of May, when the weather has become very hot and the atmosphere liable to thunder-storms. A change of pressure in the atmosphere causes an alteration in the position of the clouds, which again may cause a violent disturbance of the currents at different altitudes; the greatly heated air from warm regions is thus suddenly brought into contact with a very cold current, a sudden fall of temperature is the result, the air is no longer capable of sustaining so large a quantity of moisture, and precipitates it upon the ground. Under ordinary circumstances this water falls in the form of heavy rain, being the well-known thunder-shower; but it happens at rare intervals that the descending moisture has to pass through an exceedingly cold current of air which freezes it into solid lumps of hail, the size of the lumps being larger or smaller according to the denseness of the moisture which was falling.

VERY LARGE STONES

Very large stones have sometimes been known to fall, occasionally being as much as one and a half inches in diameter, tearing off large branches of tea by the force of their impact. Such a fall may not be of very great importance on mature tea however, because unless on very rare occasions the area over which such heavy stones fall is not great, and although the damage inflicted upon the bushes may be very considerable, yet their number is so small that even if left entirely unplucked for the rest of the season, there would be no considerable loss of crop. The size of ordinary hail is from ¼ inch to ½ inch in diameter, and when the area affected is large, and the fall is thick and continuous for more than a half a minute, the damage to tea bushes is always very serious. A high wind accompanying hail is undoubtedly the most important factor in increasing damage caused by hail-storms. It is not only that the growing flush is destroyed; the chief damage is sustained by the light twigs and branches, which have been either torn off, or their bark so lacerated and wounded that they will take months to heal again.

GARDENS SPECIALLY LIABLE

Some gardens are much more liable to hail-storms than others, especially certain hill gardens, owing to the formation of the neighbouring mountains and their influence upon the direction of air current; these gardens almost invariably suffer from hail-storms every time the season comes round.

LIGHT PRUNING

The best way to deal with such gardens is to prune lightly, and grow comparatively little in the first part of the season, so as to get the first flush off before the season for hail comes on. The bushes must in this case have more growth allowed then during the later flushes.

Not many gardens are liable to suffer by hail throughout their entire areas; it is usually only one spur

or division which is smitten during a storm. The same storm may, however, affect a long line of country in a peculiar way. On one occasion a very severe storm swept over a part of the Darjeeling and Dooars district in a narrow line of about half a mile or a mile in width and extending to forty or fifty miles long. Along the course of this storm all houses had the windows on the exposed side completely denuded of glass, and the tea-bushes stripped of leaves and small twigs, the ground under the bushes being literally strewn with the debris.

TREATMENT

When bushes have been severely smitten by hail, the wreck looks very appalling, and it is no wonder that some planters have been tempted to think that the only way to get them into condition again is to re-prune them. This is a mistake, especially if the tea is at a high altitude where growth is slow. If in good cultivation and general health, the bushes will soon begin to throw out a new flush; it is then very important to allow the flush to grow well before plucking, so that new wood may be formed before the bush is made to yield much crop; this is made necessary by the fact that all the young soft bark existing at the time of the storm has been more or less damaged. If at this stage anything like hard or close plucking is resorted to, the crop of the succeeding year will probably suffer seriously.

The tea made from leaf grown after severe hail is invariably of poor quality. It seems that the tea bush makes a special effort to cover itself quickly with leaves and so replace those which have been destroyed. This results in rapid vigorous growth and the leaf is in character similar to first flush leaf off pruned tea.

As a means of encouraging a rapid growth of leaf, to replace that torn off by the hail, the application of a quick acting manure such as nitrate of potash at the rate of 300 lb. per acre has been recommended.

APPENDIX I

FORMULAE FOR SPRAY FLUIDS, ETC.

(1) *Lime Sulphur (about 8° Be)*

Quicklime	...	... 20 lbs.
Sulphur ...	...	... 22½ lbs.
Water ...	...	... 50 gals.

The lime is slaked with water, and then brought to the boil with 25 gallons of water. The sulphur is added gradually, stirring vigorously, and the solution made up to about 40 gallons. After 1 hour's boiling the solution is made up to 50 gallons, the solid matter allowed to settle, and the clear solution drawn off and diluted as required.

(2) *Lime Sulphur (20° to 25° Be)*

Quicklime	...	... 50 lbs.
Sulphur ...	...	... 100 lbs.
Water ...	...	... 50 gals.

The lime is first slaked by adding it gradually to a depth of about 6 inches of water in the bottom of the cauldron in which the boiling is done. The heating is commenced and sulphur is added together with enough water to make a thin cream of the whole mass. The mixture is stirred vigorously and the remainder of the water, plus a few gallons extra to allow for loss in boiling is added. After not more than ¾ hour further boiling the mixture should be a deep amber colour and is allowed the cool and settle overnight. It should then be decanted off into drums for storage.

(3) *Burgandy mixture for Black Rot*

(*a*) *Adhesive.*—

Washing soda ...	...	10 lbs. (or 3¾ lbs. soda ash).
Common rosin ...	...	20 lbs
Water	...	10 gals.

The water is heated and the soda added. The solution is brought to the boil and the rosin added, with continuous stirring till dissolved.

(*b*) *Copper sulphate solution.*—

Copper sulphate takes some time to dissolve, so the solution should be prepared the day previous to spraying. 4 lb. of copper sulphate are suspended in a bag in 20 gallons of water, in a barrel or other *wooden* vessel. At the same time 1½ lbs. of soda ash (or 3½ lbs. washing soda) are dessolved in 20 gallons of water in a separate container.

Before using, half a gallon of adhesive is mixed with the 20 gallons of soda solution; this is then added slowly, with vigorous stirring, to the copper sulphate solution. If a wooden vessel is not available, an iron tank carefully painted inside with bitumen paint may be used, but if this paint does not completely cover the metal, the latter will be eaten through by the copper solution.

(4) *Caustic wash for Scale insects*

Caustic soda (commercial) ...	2 lbs.
Water	10 gals.

The caustic soda is added slowly to the cold water with stirring to prevent caking of the caustic soda and development of excessive local heat.

(5) *Another equally effective caustic wash is made up as follows*:—

Washing soda	7 lbs. (or Soda ash 2½ lbs.)
Quicklime	2 lbs.
Water	10 gals.

This leaves a white coating on the treated bushes, making it easy to check the work done.

APPENDIX II

DILUTION TABLE FOR LIME SULPHUR

The strength of solution used should be such that the parasite is immediately killed, but no serious harm done to the young growth on the plant.

Reading of hydrometer in cold solution.		Amount of water to be added to one part of the concentrated solution.				
		Cold season.		Growing season.		
In degrees Baumé.	In specific gravity.	Heavy pruned tea without buds.	Heavy pruned tea with buds; and all other tea.	Ordinary tea.	Heavy pruned and young tea.	Nurseries.
8	1·057	2	3	6	7	8
9	1·064	2¼	3¼	6½	7½	8½
10	1·072	2½	3½	6¾	7¾	9
11	1·080	2¾	3¾	7½	8½	9¾
12	1·088	3	4	8	9¼	10¾
13	1·096	3¼	4½	8¾	10¼	11¾
14	1·104	3½	5	10	11½	12¾
15	1·113	3¾	5⅓	10½	12¼	14
16	1·121	4	5⅔	11¼	13½	15
17	1·130	4¼	6	12	14	16
18	1·138	4½	6½	12¾	14¾	17
19	1·147	4¾	7	13¼	16	18¼
20	1·157	5	7½	14¾	17¼	19¾
21	1·166	5¼	8	16	18½	21¼

APPENDIX II—*concld.*

Reading of hydrometer in cold solution.		Amount of water to be added to one part of the concentrated solution.				
		Cold season.		Growing season.		
In degrees Baumé.	In specific gravity.	Heavy pruned tea without buds.	Heavy pruned tea with buds; and all other tea.	Ordinary tea.	Heavy pruned and young tea.	Nurseries.
22	1·176	5½	8½	17	20	22¾
23	1·185	6	9¼	18¼	21¾	24¼
24	1·195	6½	9¾	19½	22¾	26
25	1·205	7	10½	20¾	24¾	27¾
26	1·215	7½	11¼	22¼	25¾	29½
27	1·225	7¾	11¾	23¼	27¼	31
28	1·235	8¼	12¼	24½	28¾	32¾
29	1·245	8½	12¾	25¾	30	34¼
30	1·256	9	13½	27¼	31¾	36¾
31	1·267	9¼	14	28	32¾	37½
32	1·278	10	15	30	35	40
33	1·289	10¼	15½	31	36	41¼
34	1300	10¾	16¼	32¼	38	43¼
35	1·302	11¼	16¾	33¾	39¼	45

APPENDIX III

SOME PUBLICATIONS ON PESTS AND BLIGHTS OF TEA BY THE INDIAN TEA ASSOCIATION

Pest or blight.	Author.	Date.	Publication.
Red Spider	E. A. Andrews	1928	I. T. A. Quarterly Journal. Parts II and IV.
	C. J. Harrison	1938	I. T. A. Memorandum No. 2. "The Occurrence and Treatment of Red Spider on Tea in N. E. India."
Tea Mosquito Bug ...	E. A. Andrews	1923	I. T. A. Pamphlet. "Factors affecting the Control of the Tea Mosquito Bug."
Green-fly	E. A. Andrews	1927	I. T. A. Quarterly Journal. Part II.
Thrips	E. A. Andrews	1925	I. T. A. ,, ,, Part II.
Bark-eating Borers and Caterpillars.		1938	I. T. A. Memorandum No. 1. "The Occurrence and Treatment of Bark-eating Caterpillars and Borers."
Other Caterpillars ...	E. A. Andrews	1929	I. T. A. Quarterly Journal. Part III.
Pests of Tea and Shade Trees.		1931	I. T. A. ,, ,, Parts III and IV.

White Ants	E. A. Andrews	1923	I. T. A.	Quarterly Journal. Part IV.
	F. P. Jepson	1926	I. T. A.	,, ,, Part III. (Reprint from *Times of Ceylon*, 9th July, 1926.)
Tea Seed Bug	E. A. Andrews	1930	I. T. A.	Quarterly Journal. Part I.
Blister Blight	A. C. Tunstall	1927	I. T. A.	,, ,, Parts I and IV.
Black Rot, Thread Blight and Nectria.	A. C. Tunstall	1925	I. T. A.	,, ,, Part II.
		1928	I. T. A.	,, ,, Part I.
Red Rust	A. C. Tunstall	1928	I. T. A.	,, ,, Part IV.
Brown and Grey Blights ...	A. C. Tunstall	1927	I. T. A.	,, ,, Parts III and IV.
Other Stem Diseases ...	A. C. Tunstall	1931	I. T. A.	,, ,, Part III.
Root Diseases	A. C. Tunstall	1929	I. T. A.	,, ,, Parts I and II.
		1930	I. T. A.	,, ,, Part I.
Notes on Root Diseases of Tea in N. E. India.	A. C. Tunstall	1940	I. T. A.	Memorandum No. 8.
Red Rust	A. C. Tunstall	1942	I. T. A.	,, No. 14.
Stem Diseases of Tea ...	A. C. Tunstall	1947	I. T. A.	,, No. 16.

Other Publications.

Watt and Mann.—"The Pests and Blights of the Tea Plant." Calcutta.

T. Petch.—"Diseases of the Tea Bush." London, 1923.

CHAPTER XIII

PLUCKING OF TEA LEAF

FUNCTIONS OF LEAVES

As the tea bush is grown with the sole object of producing leaves, it is of the utmost importance that the planter should fully appreciate the functions which leaves perform in the general economy of plant growth. No system of cropping or treatment can be correct or fully remunerative unless in full sympathy with the principles which govern the production of leaf.

Although everyone knows that all kinds of plants are dependent upon their leaves for some sort of respiration, the importance of the functions which leaves perform in the economy of a plant is not generally appreciated. The activities of a plant are mostly exhibited at its extremities. While the roots absorb plant food from the soil in a fluid state and send it up the stem, such food is nevertheless in a form which is quite unfit for assimilation until it has been elaborated in the cells of the leaves, where it is treated under the influence of sunlight in the atmosphere.

Plant tissue consists of complex substances such as carbohydrates, proteins and other substances as for example tannins, alkaloids, guns, resins, etc.

The "raw materials", from which all these complex substances are made, are comparatively very simple compounds. From the soil, via the roots of the plant, various salts are absorbed, chief of which are nitrates, sulphates and phosphates of potash, lime, magnesia and soda and a large number of other minerals, some in extremely minute proportions, but often, nevertheless, essential to the well-being of the plant. All these substances are drawn up in solution in water, to the leaves of the plant. The leaves are continually absorbing carbon dioxide from the air. Under the influence of

the light rays which are absorbed by the green chlorophyll layer in the leaves, carbon dioxide and water are built up into carbohydrates such as starch and sugars, and are also combined with nitrates and other substances absorbed from the soil, to form proteins. While the plant is growing rapidly and vigorously it uses up the carbohydrates, proteins, etc., almost as fast as they are manufactured, in order to produce the new growth. In periods of dormancy, however, supply exceeds demand and reserves are stored up. Thus a tea bush at the end of the cold weather before the spring flush commences is found to be high in reserve food, as measured by the starch content of its stem and roots. As soon as the new season's growth commences these reserves are used up, and while vigorous growth continues during the flushing season, reserves generally remain low. At the end of a *banjhi* period after the bush has been producing slow growth for a spell, the reserves may be found to have increased somewhat, but are again reduced to a low level as soon as growth again becomes vigorous.

It is thus easy to see that the removal of too much leaf during the growing season leaves the bush without reserves of new material for growth and with inadequate means of producing such new material.

The bush is thus starved although there may be ample reserve of plant food in the soil. In order to maintain maximum crop and health of the bush, then not only must there be adequate manuring, but the bush must always have sufficient leaf in order to make use of the manure.

The process of building up new growth is quite interesting, and shows that the leaves are of more importance of the plant than any other part of its structure. This is a fact which must appeal to tea planters, whose whole industry is bound up in the production of tea leaves. The leaves are quite as needful to the plant, however, as to the planter himself; and things are calculated to run smoothly only when the planter recognizes this community of interest, and allows the plant to retain its fair share in due season.

An eminent scientist in horticulture wrote long ago: "Strip the leaves off a tree and no more wood will appear until the leaves are restored; feed its roots in the hope of thus compensating for the loss of its leaves and the stem will be filled with watery matter, but the latter will collect in the interior until it forces its way through the bark, and runs down in putrid streams, as happens to the mulberry-tree when it is incessantly stripped for silk-worms, and as occurs to trees whose leaves are continually destroyed by a noxious atmosphere. Strip the ripening green grapes of their green garments and no colour or sweetness will be collected in their berries. Rob the potato of its foliage, and you will seek in vain for nourishment in its tubers; and so of all things else". It is true that fruit-growers at certain season resort to defoliation or summer-pruning, but only to a partial extent for the definite purpose of letting a little sunshine reach fruit or wood. It is a well-known fact that if a fruit branch is denuded of leaves, either by hand or by insect pest, the fruit must inevitably die and drop off. Gardeners all know that a plant is healthy in proportion to the quantity of its foliage. If a fruit tree shows signs of exhaustion the gardener nips off more or less of the young fruit, perhaps all of it, for one year, in order that all nourishment elaborated by the leaves may go to restore the failing health of the plant. The scientific study of forestry has demonstrated, among other things, that the formation of timber in a tree is in proportion to the extent of its foliage. In rubber trees also, the quantity of latex secreted is in proportion to the crown of the trees. If a tree is stripped of some of its branches, the thickening of timber during the succeeding year is proportionately reduced. Exactly the same thing happens if a tree becomes infested by insect pests which strip it of leaves during the growing season.

DEFOLIATION

An evergreen plant or tree is always seen to be covered more or less with a mantle of green leaves. But they are not always the same leaves. This is a fact which

is not readily noted by the casual observer. During the season of activity the tree produces new leaves at its outer extremities, and it casts off the old leaves in succession as they are no longer required. At the point where an old leaf has been cast off to-day there is a green stalk; in a few months it will be a twig, whose epidermis has become bark; in course of years the twig may become a branch and finally a great arm of a wide-spreading tree. Thus the tree expands and increases in every direction; preserving all the while its crown of green foliage; but the foliage is always under process of renewal, while every part of the tree is changing in character or size.

The difference between evergreen and deciduous trees is not that the former retain their leaves all the time, but that while in leaf all the time they cast off and renew their leaves individually; whereas the latter class cast them off all at one time, becoming naked for a season. The general impression is that all deciduous trees shed their leaves in autumn; and that the reason is to be found in the approach of winter. The prime reason is quite different, however. It is simply that in course of time the leaves become effete and useless; they have to be cast off some time, and the autumn season is the most suitable for most trees in cold and temperate climates. In India, the phenomena of natural defoliation present many interesting characteristics. The Pipal tree (*Ficus religiosa*) preserves its beautiful foliage throughout the winter; then in spring, when all other vegetation is bursting into new growth, it sheds its leaves and takes on a dried-up look for a time. Similarly, the Toon tree (*Cedrela toona*) sheds its leaves in August, becoming naked and apparently dead at the very time when almost all other vegetation is making the most luxuriant and rapid growth. From September onward the Toon rapidly covers itself again with the beautiful, dense dark foliage for which it is so distinguished.

Thus there is an automatic discard of old leaf which is no longer capable of performing its function efficiently, in favour of new leaf.

PLUCKING OF TEA

The process of plucking shoots from the tea bush can be regarded from two points of view :—

(*a*) The severity (or hardness) of plucking.

(*b*) The fineness or coarseness of the plucked shoots.

HISTORY OF PLUCKING

The history of modern methods of plucking dates from about 1855 when Mr. George Williamson was manager of the Assam Company. Previous to this the maximum crop of tea from this Company was 3½ maunds tea per acre. The biggest yield was in April and the season practically ended in September. The reason was that leaf was plucked as soon as it grew, without leaving any initial growth. The monthly out-turns of a garden of about 700 acres were :

March	...	130	maunds
April	...	510	,,
May	...	450	,,
June	...	470	,,
July	...	400	,,
August	...	300	,,
September	...	240	,,

Williamson realized that the tea bush should be allowed to grow before plucking and when he tried this, alarm was caused by crop shortage in March and April. The result at the end of the year however was a remarkable increase in crop. This started the problem of how much initial growth to leave, and is still a most difficult matter for a manager to decide. The tendency has been to go to the opposite extreme and leave too much, or more often, too many leaves after initial plucking. Too much or too little growth means loss in crop, and in the latter case, deterioration of the bush also.

A long growth left on the bush improves the condition of the bush, and where crop is not of major importance, as for example in the case of young tea and

First Plucking.

Banjhi Shoot.

cut back tea, liberal treatment in this direction is desirable. On strong tea, well manured, it has been shown that 6 inches of new growth is sufficient on plains gardens and does not cause any deterioration over a period of several years at least, as far as crop is concerned.

PLUCKING AND HEALTH OF BUSH

It is generally accepted that some bushes, on some soils, and in some climates, will stand harder plucking, for longer periods, than other bushes under other climatic and soil conditions. To a great extent the food supply available to the bush must determine the extent to which a bush can be plucked without deterioration. The most efficient method of plucking the crop from the tea bush will be that which obtains the maximum crop of highest quality for an indefinite period of years; as much of this crop as possible being made during the "quality periods" of the season. A bush which is too hard plucked will not maintain its crop, or possibly, the quality of its leaf, over more than a year or two without showing obvious signs of deterioration; while too light plucking results in needless loss in crop annually. This loss may frequently be that of the best quality leaf.

Variations in severity of plucking may take one of the following forms:—

(1) Variation in the length of new growth allowed, before tipping to establish a plucking surface.

(2) Variations made during the season in the closeness to which shoots are plucked to the original surface established by tipping.

(3) Leaving the bush unplucked during some portion of the season.

In plucking mature top-pruned tea, lengths of new growth left before tipping commonly vary between 4 inches and 8 inches. Four inches is considered to be a very short length of new growth, and to constitute very hard plucking. Eight inches is a fairly long growth, and it is recognized that crop is lost in early years by leaving so long a growth. It is however often employed when

tea is thought to be unable to stand harder plucking without deterioration.

Indeed the tendency now is to regard plucking closer than 8″ as unnecessary, particularly with modern jats of tea, and certainly many gardens obtain crops of over 15 mds. per acre with even lighter plucking.

RESTING IN THE RAINS

On many gardens, especially in days of restriction on crop, it was a common practice to pluck a section hard until after the second flush period, and then to rest it by leaving it unplucked for a time, perhaps even for the rest of the season. If such a section is required to give leaf later on in the season it may be "skiffed" with a knife so as to establish a fresh plucking surface. The use of rains-skiffed tea is discussed later.

FLUSHES

The growth of the tea plant, like other plants, is not maintained at a continuous rate, but periods of rapid growth alternate with periods of dormancy. The new shoot which a bush produces in the spring makes a certain amount of growth and then becomes dormant, the terminal bud at this stage being small and thin, and what is commonly termed "*banjhi*". After a time growth again goes on, and again a certain amount of growth is made before another dormant or *banjhi* period. The number of such periods of growth which a shoot would go through in a season (assuming it were left unplucked) is not more than five, often less. The term "flush" which has been somewhat loosely applied in the past, can more strictly be applied to mean the amount of growth which one terminal bud will make between two successive *banjhi periods*. It is not difficult to demarcate the successive flushes on a shoot, because when the *banjhi* shoot commences to grow, small unserrated leaves called *janams* are first produced, before the normal sized, serrated and pointed leaves are developed. These *janams*

indicate the points where the shoot was *banjhi*, or in other words, they mark off the successive flushes on the shoot.

In practice a bush is tipped at a certain height from the pruning level, or from the ground, and many shoots are "decapitated" before they have finished their first flush, i.e., before they have gone *banjhi* for the first time. Many shoots however, especially if a long new growth is left in tipping, do reach the *banjhi* stage before reaching the tipping level. Many of these are tipped during their second period of growth, but there are many shoots—those which arise from low down in the frame of the bush for instance—which never make sufficient growth to come up to the plucking level at all.

HEIGHT OF TIPPING

It is a matter of importance therefore, to decide correctly the height to which a bush should be tipped. If tipped at too high a level, a large percentage of shoots will have gone *banjhi* and are not tipped. The second flush will be much later in coming away and will be much smaller than if the tipping had been closer to the pruning. If however the bush is tipped at too short a growth, although a larger and earlier crop of second flush tea will result, the bush may suffer from insufficiency of leaf left on it, and become weakened and more liable to disease.

It is common to tip healthy mature tea to 6 or 7 inches of new growth, over annual pruning. Weak sections are often allowed 8 inches or more. China bushes, especially in hill gardens, are generally plucked to about 5 inches, as on these bushes the leaves are normally closer together on the stem. Young tea, and tea which has been cut back, is generally tipped to a measure from the ground—commonly 28 to 32 inches. With unpruned tea, tipping is generally very close, often simply a continuation of plucking from the previous year. Where the bushes have been lightly skiffed to level their surfaces, it is common to tip so that one new leaf is left all over the surface of the bush. With deeper skiffing two, and sometimes three new leaves are left.

Whatever the height of tipping it is important that nothing shall be plucked below this height. It is considered one of the worst crimes to "put the hands into the bush", except perhaps at the very end of the season.

Having established the tipping level, i.e., the minimum plucking height on the bush, by careful plucking of the terminal shoots to a certain level, either from the ground or from the pruning height, there is a lull in the plucking until the "second flush" comes through. This consists of secondary shoots growing from the axils of the leaves on the green stems below the tipping level. These, together with a certain percentage of primary shoots not tipped in the first flush and a certain percentage of tertiary shoots, comprise the "second flush" crop which is such a valuable part of the season's yield in many gardens in North-East India, and which extends over the months of May and June in Assam.

PLUCKING AFTER TIPPING

It is the commonest practice nowadays to "pluck to the janam" after tipping to a certain level. By this is meant that all growth above the tipping level is plucked off level with the tipping level, except that the small *janam* leaf is not plucked, if it happens to be above the tipping level. Fig. 12 (page 263) shows how shoots of various types are plucked. A marks the first tipping, B the plucking of secondary shoots (second flush), level with the tipping height. C is a plucking just above the tipping level, the *janam* leaf being actually at the height of this level. D is the place at which a shoot consisting of two open leaves and a bud will be plucked. The plucking level thus inevitably rises somewhat in plucking to the *janam*, as the season progresses, until it is perhaps 3 or more inches higher at the end of the season than the original tipping level. This very general system of plucking maintains a flat and easily plucked surface to the bush, and provided the original tipping left not less than 6 inches of new growth, is not considered too severe for well-manured, vigorous, mature tea.

Weak tea may well be plucked *without* breaking back, over a tipping height of 8″. A flat plucking surface is not, of course, maintained, but the bush benefits greatly by the extra leaves left on the bush during the course of the plucking season.

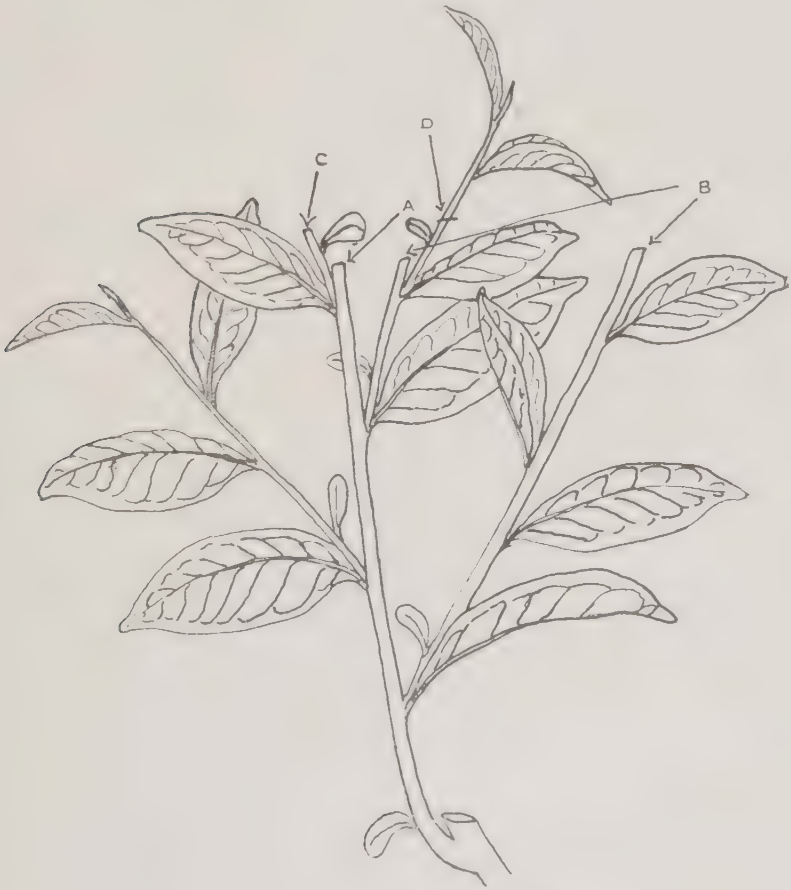


Fig. 12. Modern System of Plucking.

FINENESS OF PLUCKING

In the above reference to Fig. 12 it is stated that the unplucked shoot will be plucked at D having two leaves and a bud. This is normal for gardens making good, or good average, quality teas. Many gardens which go in for cheapness of working and make useful but "common" teas, may leave shoots to form three or

even four leaves above the *janam* leaf, before plucking them. On some of the finest quality gardens, however, shoots of one leaf and a bud may be plucked, especially if the shoot is a fairly big one. What usually happens is that, as a result of say a week's growth, there are pluckable shoots of one, two, three and possibly four or more leaves, depending on how closely the bush was plucked on the previous occasion. It is a matter of judgment of individual managers as to what size of shoot shall be plucked, and what left as immature. Coarser plucking results in a larger crop but poorer teas, and a smaller percentage of fine grades. The cost of plucking coarsely is naturally less than that of fine plucking.

BREAKING BACK

Supposing a manager insists on leaf of a certain standard, say, nothing coarser than 3 leaves and a bud; and it is found that some shoots on the bush have produced four leaves above the *janam*, or above the plucking level. If three leaves and a bud only are plucked, a leaf is left above the *janam* on the remaining shoot, and sticks up above the plucking level. In order to maintain the flat surface of the bush, and to prevent the plucking level from rising unduly, such extra leaves may be "broken back" to the *janam* or plucking level, and thrown away. The effect of leaving such extra growth on the bush, instead of breaking it back, is to make subsequent plucking more difficult owing to the uneven plucking surface obtained, though of course the pluckers waste a certain amount of time in breaking back. No appreciable loss in crop occurs however from not breaking back, while the vigour of the bush is improved to some extent by leaving the leaf on the bush. In the case of weak, cut back, or young tea, it is thought advisable not to break back long shoots. On healthy tea, if plucked at 6 or 7 days' intervals, taking a good standard of leaf, and all the leaf which is "ready", there is little breaking back to be done, and it is desirable to maintain the flat

level surface by breaking back the few long shoots which may occur.

On a few gardens, an extremely hard form of plucking has been tried. This consists in breaking off everything, including the *janam*, which appears above the original tipping level. This is a practice which few planters would advise, or dare to pursue themselves. Bushes so treated look very debilitated at the end of the season, and there is really no benefit either in crop or in the quality of the tea made.

PLUCKING OVER LEAVES

At one time it was very general, after tipping to a measure, or over a certain number of leaves, e.g., three leaves, not to pluck to the *janam*, but to again leave one or two leaves over the tipping level. After that, perhaps the plucking would be over another leaf, and finally, about August or September, plucking for the rest of the season would be to the *janam* (*see* Fig. 13). While this maintained the bush in a vigorous condition, crops were very low and it is seldom that this system is seen nowadays. One objection to the system was that the strong centres of the bush were plucked more lightly in comparison to the sides, owing to the fact that the length of stalk between leaves is on the average greater with strong growing shoots. Moreover, the side shoots come out at an angle, and on these a certain number of leaves means a smaller vertical height than on vertically growing centre shoots. Thus the bush assumes a convex plucking surface, making plucking and supervision of plucking more difficult. There was a tendency with this system of plucking to be too hard on the sides of the bush, which were thereby prevented from spreading and covering the soil. A better system than this, if a less severe form of plucking than keeping down to the *janam* is desired, would be either to increase the amount of growth left at the time of tipping or to raise the plucking level later in the season by the same amount all over the bush, still maintaining a flat surface.

EFFECT OF VARYING THE TIPPING HEIGHT

The effect on crop of varying the initial length of growth on pruned tea is that for initial lengths varying between 4 and 10 inches, there is a loss on good average

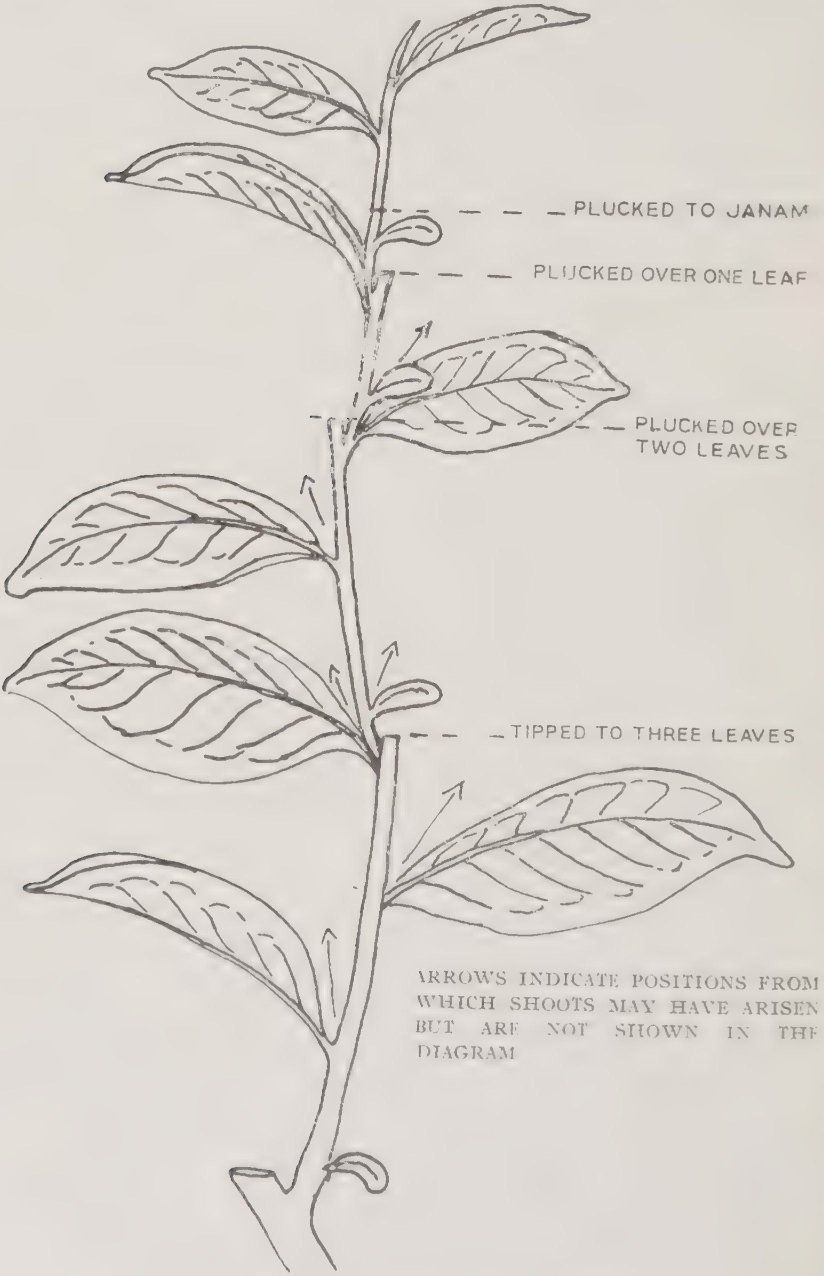


Fig. 13.—Old System of Plucking.

tea for at least two or three years, of about 10 per cent in crop, a great deal of it good second flush leaf, for every extra two inches of initial growth left. Gradually however this loss decreases, especially between the tea plucked to the shortest initial height, and that which is tipped to a rather more liberal measure. It is not that the lighter plucked tea improves, but that the hard plucked tea tends to deteriorate under the hard plucking. A bush must have a certain amount of leaf left on it in order that it shall remain healthy, and no amount of manure will compensate for a continual deficiency of leaf, whether caused by hard plucking or for any other reason.

EFFECT OF LEAVING GROWTH LATER IN THE SEASON

Actually, a very vigorous bush tipped to say 4 or 5 inches, may have plenty of leaf on it to maintain its health and vigour for some months, but when these original leaves age and lose part of their efficiency as "factories" for the manufacture of material for new growth, the bush may begin to suffer from shortage of leaf. When this happens, the obvious remedy is to leave additional new growth instead of plucking continuously to the *janam*. The bush can be plucked to the *janam* over, say, 4 or 5 inches of new growth up till the end of the second flush, and then allowed growth of one leaf over this level, and then plucked again to the *janam* to the end of the season over the new level established after leaving a leaf. A larger second flush, but a smaller rains crop will result compared with plucking to an initial height of say 7 or 8 inches and then to the *janam* throughout the season. The total crop over the season will be about the same in both cases.

For Assam gardens, whose second flush teas are of the greatest value to them, a system of early close plucking followed by leaving a leaf, or by raising the plucking level say 2 inches, would be an excellent way of increasing the percentage of their second flush crop. Not only so, but there is the additional advantage that

quality of late rains and autumnal teas is certainly better off bushes so plucked than off bushes plucked to the *janam* over a certain initial height.

RAINS SKIFFING

When a garden is able to make its restricted crop comfortably, or when there is a temporary shortage of labour for plucking during the rains, it is common to leave certain sections of tea unplucked for a week or more, and to bring them back later into the plucking round by skiffing off the unplucked growth with knives or sharpened bamboos. As a general rule, providing it is not too long, the interval between the skiffing and the next plucking is about equal to the interval between the skiffing and the previous plucking. For instance, if bushes were plucked up to and including the 31st of July, left unplucked during August and skiffed on the 28th of that month (4 weeks later), the bushes will be pluckable on about the 25th of September, four weeks from the time of skiffing. If unplucked for 14 days and then skiffed, a section will normally be pluckable again 14 days later.

The amount of crop lost by leaving unplucked and then skiffing depends of course partly on the length of time the bushes were left unplucked, and partly on the height of skiffing. Least crop is lost by skiffing down to the original plucking height, but this is not desirable. Better autumnal teas are made if, in skiffing, an extra growth of one or two leaves about the original plucking level is left. Moreover it is better for the health of the bush to leave a growth at least one leaf when skiffing, instead of going down to the original plucking level.

As a rough guide, the following results on rains skiffing may be quoted. Healthy tea gave about 12 maunds per acre when plucked to 6 inches and close to the *janam* throughout the season. Exactly similar tea gave $4\frac{3}{4}$ maunds tea per acre to the end of July plucked at 4 inches to the *janam*; no crop in August, being left unplucked, and 3 maunds per acre for the rest of the

season after skiffing, leaving two leaves, at the end of August. Again similar tea, after giving $4\frac{3}{4}$ maunds per acre to the end of July, was left unplucked for a fortnight, and plucked over an extra growth of two leaves, 14 days from the previous plucking. This tea gave $4\frac{3}{4}$ maunds tea after being left unplucked, making a total of $9\frac{1}{2}$ maunds per acre for the season. In both cases, the teas made in October and November were markedly better than that from bushes plucked throughout the season to the *janam*.

The splendid appearance of the bushes hard plucked in the early part of the season and spared later in the rains was very marked, and shows that under this system the health and vigour of the bushes improves. No such improvement is seen, however, unless new growth is left on the bushes after resting them from plucking. The losses in crop from resting are admittedly very heavy, but could be reduced by leaving new growth of only one leaf, or by reducing the time the bushes are left unplucked.

It is of little use to skiff bushes left too long unplucked or left unplucked too late in the season, with the object of getting a good crop of autumnal leaf. If left too long unplucked, the skiffing will have to be on red wood and the teas made will be much like that from tippings off pruned tea.

Weak sections or cut back tea may be plucked up to the end of the second flush and let go when labour shortage due to rice planting occurs. It is seldom worth while however to bring such sections back into the plucking round again.

INTERVAL OF PLUCKING

In order to make the maximum crop of good quality leaf on plains gardens, a seven-day round of plucking is certainly not too short. In fact, even if all ready leaf, including large shoots of one leaf and a bud and anything larger, is plucked, there is bound to be a certain percentage of three and a bud shoots in the baskets.

If orders are to take nothing larger than two and a bud shoots, there will have to be a good deal of breaking back and throwing away of the third leaf, with resulting waste of time and crop. Many gardens which pluck fine leaf keep to a six-day interval as far as possible. To pluck really good leaf at 6 and 7 days' intervals on an average plains garden, a plucking force averaging between one and one and a quarter plucking operatives per acre is required, during the busy season.

Gardens in non-quality district which go "all out" for cheapness of working, often pluck at 8, 9 or 10-day intervals, even longer at certain periods of the season. Coarse leaf is taken, but crops are often very large, and the cost per lb. of leaf is low.

BANJHI LEAF—AUTUMNAL LEAF

There is always a certain percentage of pluckable shoots which have become dormant or *banjhi*. This percentage fluctuates in inverse ratio to the flushing or growth of the bush. *Banjhis* should always be plucked, retaining the topmost *banjhi* leaf if soft, but discarding it if hard. "Double *banjhis*", i.e., shoots consisting of a *banjhi* bud and two leaves, are generally plucked and included in the basket, on gardens which go in for "free' plucking. A glance at the withered leaf on the racks will however show that such double *banjhis* wither extremely slowly, much slower in fact than normal shoots of three and four leaves. Double *banjhis* are usually hard and stalky, and do not contribute towards good teas, either from the point of view of appearance or liquors. *Banjhi* leaf above the plucking level should however be plucked, even if not put into the baskets for manufacture, since crop is reduced by leaving them on the bush, apart from the loss of crop and time resulting from plucking over an uneven plucking surface. Towards the end of November and during December, growth is slowed up by reduced temperatures and low moisture content in the soil. The leaf becomes harder and has a bigger proportion of *banjhi* but is

often flavoury and makes good tea—good that is in liquor, though often red, flaky and poor looking in appearance. Buyers however do not mind the appearance, if the teas have true autumnal character in the liquors. Plucking in the autumnal period is generally freer than earlier in the season, everything which will make tea being plucked. It is thought by many planters that it pays to increase the plucking interval to 10 or 14 days or even longer during the autumnal period, in order to get the best flavour in the teas.

PLUCKING OF UNPRUNED TEA—COLD WEATHER SKIFFED TEA

The first flush off unpruned tea is a large one and compares very favourably in quality with that from the tippings off pruned tea. Unpruned tea should be plucked as close as possible so as to get the full benefit of this early crop. Unless plucking is close, much *banjhi* leaf will remain unplucked just above the previous season's plucking level and will not come away till some time later. The harder unpruned tea is plucked from the start of the season, the better will be the teas, and the larger the early crop made. Later on, after the second flush, it is often the rule to abandon plucking of much of the unpruned tea, when it is producing small hard shoots and *banjhis*, difficult and expensive to pluck. After the first flush is off, subsequent teas from unpruned bushes are of poorer quality throughout the season, than those from top pruned bushes.

The plucking of tea skiffed in the cold weather depends on the depth of skiffing. If skiffed very lightly simply to level off the plucking surface, it may be plucked hard, as for unpruned tea. If the skiffing is into red wood, the plucking should be over one or two new leaves, according to the depth of skiffing.

YOUNG AND CUT BACK TEA

It should be a hard and fast rule never to pluck young or cut back tea closer than 28 or 30 inches from the ground, except perhaps in the case of China bushes

on hill gardens. Even there, 24 inches should be regarded as a minimum.

As crop is generally not wanted from such tea, plucking is done simply with the object of checking growth of the strong centre shoots and encouraging a more or less even thickness of wood over the frame of the bush. There is no object in keeping strictly to the tipping level, in fact to save time there need be no breaking back done. It has been found that the pruning cuts on bushes cut back to 18 inches and plucked to 32 inches with no breaking back, callus as well, or better, than any other system of plucking, even than leaving the bush unplucked altogether. It is not wise to pluck young tea, if unpruned in its second year in the ground, as hard and close as one would pluck mature unpruned tea. Again crop is not the major consideration, and a growth of 2 to 6 inches over the previous season's plucking level should be left.

LEAF BASKETS

In Assam the pluckers usually have bamboo baskets capable of holding about half a maund of leaf. In the Dooars and Darjeeling conical shaped baskets of cane are used, slung behind the back by a band passing across the forehead. In some gardens women pluck into cloths, the contents of which are tipped into a large basket at intervals. Everything possible should be done to ensure that leaf is not pressed down in a basket or left for a long time in a large bulk closely packed; as bruised and reddened leaf is almost certain to result. Leaf even before it is plucked carries on its surface undesirable bacteria, and any heating which takes place after plucking, especially if the leaf has surface moisture on it, is bound to cause rapid multiplication of bacteria, with harmful effects on the teas made. Very special attention should, for this reason, be taken with plucked leaf, from the time it is taken off the bush, to the time it is spread. In the next chapter on the weighing up and handling of green leaf, the effect of damaged leaf, and of bacterial infection is dealt with in detail.

CHAPTER XIV

THE WEIGHMENT AND HANDLING OF GREEN LEAF

JUST as systems and costs of all other cultural methods in the tea industry vary greatly from garden to garden and from one district to another, so also do the methods and costs of plucking, and means of transporting leaf from garden to factory vary.

In the early part of the season pruned bushes require very careful initial plucking for several weeks, firstly to ensure that ample new growth is left on the bush, and secondly to establish a level plucking surface. This makes subsequent plucking simpler and more rapid for the pluckers, and more easy to supervise. During this period also, so small a weight of leaf is plucked (especially if the work is done accurately), that pluckers would earn very small wages if paid at the same rates as those which obtain during the height of the season, when the yield per bush is many times greater. Moreover after the tipping has been completed the fact that a level plucking surface has been established to act as a guide, renders plucking much more rapid than when pluckers are measuring the height of each shoot before they pluck it.

Pluckers are therefore, especially on gardens which prune all their tea annually, paid a flat daily rate instead of on the weight of leaf plucked. Alternatively the rate paid is on weight, but is very much greater than the rate paid later on in the season. On gardens which have much unpruned tea, the rate may be the same throughout the season; as during the tipping period large crops from unpruned tea compensate for low crops from pruned tea.

VARIATIONS IN COSTS OF PLUCKING

On a garden which is compact, high yielding, and on which a fine standard of leaf is not insisted on, the

pluckers can bring in very much larger quantities of leaf daily than those on a scattered, low yielding garden, or on one where really fine leaf is insisted on. Thus rates per pound of leaf plucked will naturally be higher in the latter instance. There are other factors in addition which govern the price paid to pluckers for their leaf, and the real criterion of the fairness of the plucking rates is the relative contentedness of the labour force with their pay, having regard to variations in living conditions, cheapness of food, fuel and other amenities.

VARIATION IN METHOD OF WEIGHMENT

What is perhaps not quite so clear, is why there should be the diversity that exists in methods of weighing up green leaf, and recently there have been efforts on the part of the industry to introduce simpler and more standard systems of weighment, at least among gardens in the same district.

In making out its yearly budget of expenditure, a lump sum is usually allotted for cost of plucking, based on the estimated crop. Thus if the estimated crop is 10,000 maunds of tea, a sum of Rs. 40,000, or Rs. 4 per maund of made tea may be the estimate allowed for plucking. It is the conversion of this sum to annas per pound of green leaf paid to the pluckers which presents difficulties, especially if an attempt is made to average out the earnings of the pluckers throughout the season, so that they are not underpaid at some times and overpaid at others.

VARIATION IN MOISTURE IN LEAF

The matter would be comparatively simple if the tea leaf always contained the same moisture content; in other words if a certain weight of plucked leaf always gave the same weight of dry tea. As everyone knows, moisture contents vary considerably with season, pruning of the bush, climatic conditions, and even, though to

a lesser extent, with manuring and fineness of plucking. The moisture in green leaf may be as low as 74 per cent if plucked after a dry spell during the second flush; and as high as 82 per cent with rain soaked leaf. Thus from 100 lb. plucked leaf one may get at times as much as 26 lb. of tea, and at others only 18 lb. With the cost of plucking fixed at say one pice per lb. of green leaf, the cost per maund of tea might be Rs. 4-12 when leaf of very low moisture content is plucked, and as much as Rs. 7 when rain soaked leaf is plucked.

The average moisture content taken all through the season and for several consecutive seasons in mid Assam off leaf from top pruned tea, works out at $77\frac{1}{2}$ per cent. This includes wet as well as dry days, from the tipping period to the end of November. At this rate it takes 356 lb. of fresh leaf to make one maund of tea. In the table below, plucking costs per maund of tea equivalent to various rates of payment for green leaf, assuming the above ratio of tea to green leaf, are given.

Lb. green leaf, per anna.	Plucking cost per maund of tea.		
	Rs.	A.	P.
2	11	2	0
3	7	6	8
4	5	9	0
5	4	7	2
6	3	11	4
7	3	2	10

Thus if a garden paid a flat rate of one anna for four lb. of leaf (or a pice a pound) throughout the season (without cutting for wet leaf) the plucking cost would average out at Rs. 5-9 per maund tea.

Actually of course it would fluctuate during the

season from day to day according to moisture content as shown in the following table :—

Moisture in fresh leaf, per cent.	Plucking cost per maund of tea if rate is a pice per lb. green leaf.
	Rs. A. P.
74	4 12 11
75	5 0 0
76	5 3 4
77	5 6 11
78	5 10 11
79	5 15 2
80	6 4 0
81	6 9 2
82	6 15 1

In order to reduce large flunctuations in costs of plucking, and to effect some levelling up in pluckers' wages from week to week during the season, it has been customary on most gardens to cut off a certain percentage from the weight of leaf brought in by pluckers when wet leaf, covered with surface moisture, is brought in. Thus if a plucker brings in 20 lb. dry leaf, containing 75 per cent moisture, this is equal to 5 lb. dry tea. If the leaf is wet, and contains 80 per cent moisture, only 4 lb. dry tea will be obtained from 20 lb. green leaf. In order to keep the plucking rate per maund of tea the same for wet as for dry leaf, one-fifth of the weight of wet leaf would have to be deducted, and instead of paying for 20 lb. of wet leaf, only 16 lb. would be paid for.

The weight of the plucking basket also has to be allowed for, unless the pluckers tip their leaf into a specially tared basket for weighing—a practice which is liable to cause undue damage to leaf, and also to slow up the process of weighing in. It is therefore general to issue the labour force with baskets of approximately standard weight, and to set back the pointer of the scale so that, with an empty basket on the scale, the pointer

reads zero. Baskets of leaf can then be hooked straight onto the scales for weighment.

Whenever leaf weighment is done in a careless or perfunctory manner, the coolies soon display their marvellous ingenuity for taking advantage. The basket of leaf will be dipped in water to make the whole weigh heavier and so add to the extra pice ; a stone or a brick will be hidden amongst the leaf, or a false bottom may be constructed so as to conceal a permanent addition to the weight ; in some instances the basket itself is skillfully doubled or very heavy bamboo supports added to it on the plea of strengthening it.

Many gardens add a dial to the face of the scale either inside or outside the circle showing the actual weight. This dial is marked off in annas and pies so that the plucker knows exactly what he or she is being paid for the leaf.

WEIGHMENT BY BULK

A system of measuring up plucked leaf which has much to recommend it, has been tried with success on one or two Assam gardens. In this system there are no scales or weighment of leaf, except possibly in bulk at the factory. Pluckers are issued with carefully made standard baskets, holding a certain weight of green leaf (free of surface moisture), when just filled level with the top and not pressed down. The basket may be made to hold 5, 6 or more pounds of leaf, according to the conditions and rates of payment on the particular garden. For instance, a garden whose rates are say Rs. 3-11-4 per maund tea, and is paying an average of one anna for 6 lb. green leaf (see table on page 283) might have basket holding exactly 6 lb. of dry green leaf and pay one anna per basketful throughout the season. There is thus no need to cut for surface-wet leaf, since the basket holds within small limits the *same equivalent of tea* whether the leaf in it is wet or dry, although of course the weight of green leaf required to fill it will vary according to whether there is surface moisture on it or not.

With this system it is necessary to have large baskets or containers at convenient places, into which the pluckers can empty their small baskets when full; and someone is required at the spot to mark up the pluckers for the leaf they have plucked. The system if used properly has great advantages in ensuring that leaf in the best possible condition is brought into the factory. Firstly, the leaf is obviously not going to be pressed down in the baskets by the pluckers, but rather the contrary, so that it remains cool and not liable to redden. Secondly, if lorries or carts are kept going round at intervals collecting the leaf and taking it to the factory, the time which elapses between plucking and spreading in the withering house can be reduced to minimum. Thirdly, with intelligent men employed in marking up the pluckers for their leaf, a very good check can be kept on the standard of leaf they have plucked, as they empty out their baskets.

CONTAMINATION OF GREEN LEAF—REDDENING OF LEAF

There are several sources of contamination of leaf between the time it is plucked and the time it is manufactured. Leaf on the bush, before it is plucked, carries bacteria, both harmful and harmless, on its surface. Under ideal conditions however these bacteria need cause no trouble, but if the leaf, especially if wet, is pressed into baskets and left for even half an hour, it heats up and the bacteria multiply with great rapidity. The heat may also cause the leaf to redden, due to its cells being made permeable and the juices so exposed to the air becoming oxidized. Such leaf never makes good tea. All efforts should therefore be made to avoid plucked leaf being packed thick before being spread on the withering racks. If brought into the factory by the pluckers in baskets, care should be taken to see that it is not pressed down in the baskets. If brought in by carts or lorries some efficient carrier should be fitted to the vehicle.

LORRIES AND CARTS FOR TRANSPORT OF LEAF

In some gardens lorries are fitted with tiers of trays on which the leaf is spread a few inches thick with air

spaces between the tiers. This is a better system than having special square shaped baskets made into which the pluckers tip their leaf. These baskets are loaded direct onto the lorry, trolley or cart, on a framework made specially to hold them, but the leaf is very liable to pack down in the baskets and heat up in transit to the factory.

LEAF IN SACKS

Many hill gardens have ropeways for transporting leaf, and a common system is to fill sacks with leaf which are slung on the ropeway. In some cases sacks almost bursting with leaf come swinging down the ropeway and crash onto the receiving platform with considerable force, bruising the leaf inside the sack. Often too, in spite of cool climatic conditions, the leaf heats up in the sacks and may be considerably reddened by the time it is spread on the withering racks. Improvement in the transport of leaf on many hill gardens is a matter well worth consideration.

Where an out-garden is a considerable distance from the main garden and transport is slow, it is common to keep the evening leaf at the out-garden till next morning. It should in this case be spread 3 or 4 inches deep only, on a cool floor or preferably a platform off the floor in a thatched roof building, and sent off as early as possible next day.

FOREIGN MATTER

Much foreign matter often of very undesirable character may get into the leaf before it reaches the withering house. The following is quoted from the Indian Tea Association's Memorandum No. 3 (1938) on the "Elimination of Foreign Matter from Tea":—

"Close supervision during this process is admittedly difficult, as the operation is necessarily spread over a wide area. Nevertheless overseers should be impressed with the necessity of keeping a careful watch for foreign matter in plucking baskets.

Among those materials for whose presence in the

baskets a careful watch should be kept are grass and other plant leaves and stalks, tea flowers, tea seed, pieces of bamboo, broken glass from coolies' bangles or mirrors, pan leaf and betel-nut.

The presence of much broken bamboo can be avoided if leaf baskets are replaced when they become old or damaged. The manager should consider the possibility of persuading the plucking force not to wear glass bangles while actually engaged in plucking.

The picking over of leaf before or at the time of spreading it on the withering racks is an obvious means of eliminating extraneous matter introduced during the plucking process. In factories where leaf is manufactured without withering, it is essential that the leaf be carefully picked over before it goes through the tobacco cutter or chaff cutter, otherwise pieces of foreign matter are likely to be chopped up small and to escape detection and removal at later stages of manufacture. Moreover, damage to the knives of the machine can be caused by metallic objects or by pieces of cement and other hard material."

REMOVAL OF FOREIGN MATTER FROM GREEN LEAF

In addition to the above-mentioned foreign matter which may be found in green leaf, a variety of tiny insects, flies and beetles, etc., together with sand or soil inevitably get into the baskets. A very satisfactory method of removing even the smallest particles of foreign matter has been devised by Mr. T. W. Allan of the Dooars and was described at the Third Annual Conference at the Tocklai Experimental Station in 1939. The description and design of the apparatus used is worth quoting here :—

"The apparatus suggested by Mr. Allan is based on an ordinary chute for delivering leaf from the withering loft to the rolling room. A length of No. 4 or 6 wire mesh is stretched along the length of the chute, raised $\frac{1}{4}$ inch above the floor of the chute. The leaf rolls down the surface of the wire, and the sand and foreign matter, together with a small amount of

buds, falls through the wire and slides down the chute underneath the wire.

Some four feet from the end of the chute, a gap is left in the slide through which the sand and buds fall on to a second chute, at an angle to the first, the main bulk of the leaf continuing to roll along the wire mesh to the discharge.

The second chute has the same construction as the first, except that No. 8 or 10 mesh is fitted, which effectively separates the sand from the buds. Again the sand falls through the mesh and continues to slide down the chute until it reaches the gap where it falls into a box for disposal. The tip continues down the surface of the fine mesh to the discharge.

The angles of slope of the chutes should be approximately 60°.

A diagram of the apparatus is given in Fig. 14."

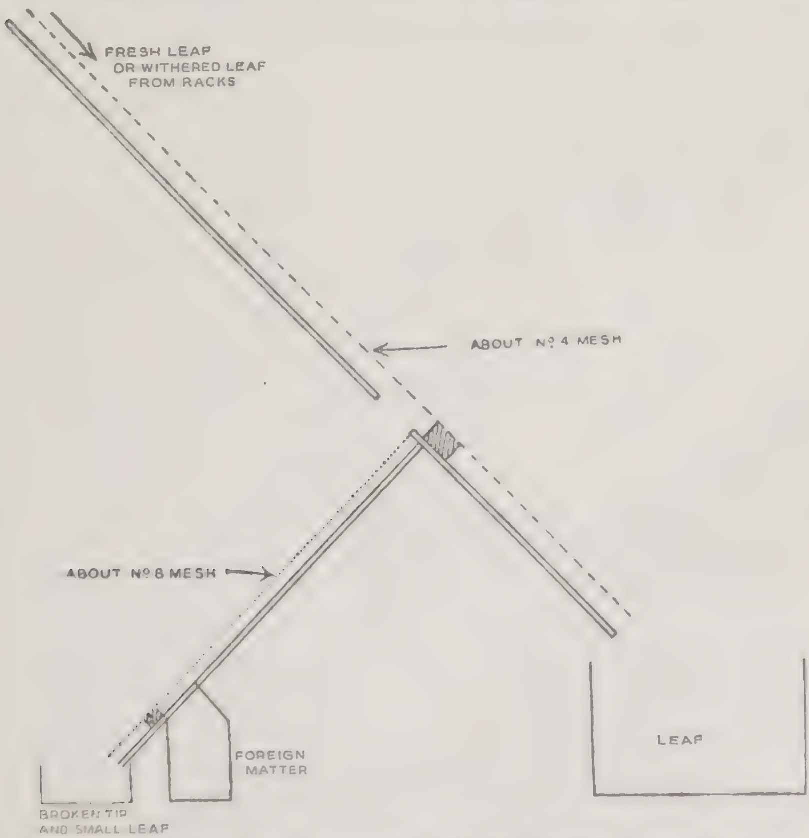


Fig. 14.—Chute for Removing Foreign Matter from Leaf.

CHAPTER XV

WITHERING

SPREADING LEAF

WHILE the assistants are engaged in examining and weighing leaf, the manager, or the factory assistant, has his hands full attending to the proper spreading of the same for withering, which is the first process of manufacture. This applies to gardens which manufacture tea and grade it according to standards laid down by the buying and selling side of the industry, as being those which the market requires. In order to produce the necessary standard of B.O.P., O.P., B.P., etc., withering of the leaf is essential. In recent years a system of manufacture in which the withering process has been eliminated, has found favour, especially in the Dooars and to a less extent in the Surma Valley. The grades of tea produced by the "no wither system" of manufacture bear little resemblance to any standard grade of tea hitherto made, but the product nevertheless has desirable characteristics and undoubtedly sells as well, if not better than, teas made previously by the gardens in question. This may be considered sufficient justification for the "no wither system" which is discussed in detail later. In this chapter, however, we are concerned only with the normal system of manufacture which was universal up to about 10 years ago, and which is still employed on gardens making the best quality teas.

The manager who has a proper interest in his work will throw the best of his energies and his utmost skill into the supervision of every detail in the factory; so much depends upon the workers being kept strictly up to the mark and prevented from falling into slovenly ways, or even into grooves and beaten paths.

OBJECTS OF WITHERING

One of the objects of withering is that the leaf may be prepared for the subsequent processes of manufacture. Were rolling attempted before withering, the result would soon be a mass of torn fragments and much juice expressed from the rollers. About 75 per cent of the fresh leaf consists of water even on a dry day, and nearly half of this has to be got rid of, before the fibre of the leaf and stalk will stand the strain of rolling without breaking up.

EARLY CHINESE METHODS

The withering process is described in early Chinese manuscripts, and its significance in the production of black, as opposed to green tea, was recognized. In one of these manuscripts, the withering process in the manufacture of *Yen*, or *Pao Chong* tea, is described thus: "After the leaves are gathered spread them upon flat trays and expose them to the air; this is called *Leang Ching*. Toss them with both hands, sift them and carefully examine them with a light to see if they be spotted with red, which is necessary: this is called *To Ching*. Carefully put them into small bamboo trays and cover them up quite close with a cloth until they emit a fragrant smell: this is called *Oc Ching*." And again in the preparation of *Yen* and *Puon Shan Souchong*: "Spread the leaves about five or six inches thick on bamboo trays (*Po Ky*), in a proper place for the air to blow on them. Hire a workman, or *Ching Fu* (to watch them). Thus the leaves continue from noon until six o'clock, when they begin to give out a fragrant smell. They are then poured into large bamboo trays (*Po Lam*), in which they are tossed with hands about three or four hundred times: this is called *To Ching*. It is this operation which give the red edges and spots to the leaves." In a book by Samuel Ball—"Tea in China" published in 1848—a chapter is devoted to the withering process. From this it appears that the process differed according to the quality of the leaf gathered.

The finest leaf, *Yen*, or *Padre Souchong*, is withered, after plucking, in the shade, but *Souchongs* and *Congous*, made from coarse leaf, are withered in the open air, exposed to sunshine.

The withering of the coarser leaf was done by spreading the leaf 5 to 6 inches thick on bamboo trays $2\frac{1}{2}$ feet in diameter, arranged in rows on bamboo stands about 2 feet above the ground and at an angle of 25° to it, facing the sun. Leaf collected after rain especially requires withering in the sun, and after some exposure to the sun is kept in the shade 24 hours and again exposed for an hour or so to the sun. The withering of the coarse leaf is often hastened by heat from stoves under the bamboo stand.

The first leaf, withered in the shade, is usually plucked during the heat of the day and after a spell of fine weather. It is spread very thinly on the trays, which are carefully shaded. An easterly wind is considered unsuitable for the withering. This completes the stage called *Leang Ching*.

For both fine and coarse leaf, there is another stage to the withering process called *To Ching*. The leaf in the trays is tossed about with the hands until red edges and spots appear on the leaves and a certain fragrance develops. It is then collected together, seven or eight trayfuls placed on one tray, and covered with a cloth. When the desired degree of fragrance is obtained and the redness develops to a certain stage, the withering process is complete. This final stage in the withering process is called *Oc Ching*, and it is of the utmost importance that this last stage is brought to its exact completion before the next process, the roasting stage, starts.

EARLY METHODS IN INDIA

Accounts of the withering process as carried out in early times in North-East India are found in several books and essays on the cultivation and manufacture of tea.

From these, it appears that planters regarded withering merely as a means of removal of moisture from

the leaf and any sign of reddening of the leaf was regarded as harmful and to be avoided.

Factors concerned in withering were considered to be sunshine, light, heat and air. Sunshine was considered of supreme importance. It is also evident that light was considered to have an influence on the wither, though the evidence advanced in this connection was questionable.

It was further considered that, light and good ventilation being assured, heat was a great accessory to rapid withering particularly in the rainy season. The influence of the humidity of the air does not seem to have been considered, the reason for a poor wither in the rains being ascribed simply to lack of sunshine.

In the dry weather, the leaf was spread thinly in the open air on trays or "machans", or on the floor, or even on the roofs of buildings. Withering on bamboo trays resting on racks was considered best and quickest. It was turned over before dark, and next morning if ready was collected and rolled. If not ready it was left for half an hour in the sunshine.

In the rains, leaf was often spread on canvas stretched on large bamboo frames. These were run up inside the tea house to the roof, where the warm air effected a wither. Every use was made of spells of sunshine for furthering the wither.

Reference is made to the general lack of withering space in the busy season, and on some gardens, withering houses well supplied with skylights to admit the maximum light were erected. The leaf spread on "chungs or trays" inside was heated by air from a furnace outside the house against one end of it. The exhaust air escaped at the other end through a chimney.

It is mentioned in later books that the exposure of leaf to sunshine in withering produces weaker teas, and that direct sunshine should only be employed for withering during damp spells.

It was considered that an under-wither gave a broken tea but one with as good a liquor as a well withered tea.

Artificial means of withering produced a rather poorer liquoring but better looking tea.

One artificial withering machine is described as having a series of drawers on which the leaf is spread. Hot air is forced over the trays by a bullock-driven fan.

In many factories artificial withering was carried on simply by suspending racks of leaf in the factory over the charcoal *chulas*, but the risk of tea-house fires from this operation is emphasized.

Attempts are described at withering the leaf by heating it in the *dholes* (basins where the tea is fired) or in heated pans. The results were not satisfactory, as the out-turn or infusion was greenish and the liquors thin and light. It was noticed that with lower temperatures there was less tendency to green infusions.

An experiment on withering is described as follows :—

Samples of leaf with the following degrees of wither were manufactured and the resulting teas compared :

1. No wither.
2. Slight wither.
3. Medium wither.
4. Over-wither.

The leaf with no wither broke up in rolling and much thin green liquor was squeezed out. The made tea was broken and reddish grey in appearance, the liquors pale, cloudy and weak, and generally tasteless. The slightly withered leaf had somewhat better appearance but still had weak and pale liquors.

The over-withered leaf gave a good roll and a little thick reddish yellow juice was squeezed out. The tea was well twisted, black and chubby. Liquors had good colour and were clear but had a "mawkish" taste.

The medium wither gave a good black tea and satisfactory liquor. The writer considered that withering should be in excess of what was generally considered satisfactory and stated that greater strength in the teas would result.

Methods of testing the degree of wither are described in early books and the methods described are those at present in common use by the majority of planters.

The tests are:—

(1) A handful of fresh leaf, if squeezed, emits a crackling sound. This should not be so with well withered leaf.
(2) A handful of fresh leaf, when squeezed and then released, springs back to almost its original size. With withered leaf, the handful when pressed into a compact ball, retains this shape.
(3) The stalk of fresh leaf is brittle, while that of withered leaf is not so, and should not break when bent double.
(4) Withered leaf has that feel, variously described as being like old rags, or kid gloves, or a silk handkerchief.

Baildon in 1877 makes some interesting remarks on withering. He advises the addition of water to the roll in the case of an over-wither. He states that an over-wither gives a black tea with golden or chrome tip, not silver-coloured as was at that time desired. He also advises varying the thickness of spreading the leaf on the trays or machans, according to the temperature; a thick spread for hot, and thin for cold days. He mentions the fact that a manager of the Jorehaut Tea Co. told him that he was installing wire netting racks for withering leaf, and considers it a scheme of very great value and one which should commend itself generally throughout the tea districts. This is the first mention one finds of the use of wire netting racks for withering.

MODERN METHODS OF WITHERING

The various types of withering houses at present used in North-East India are of two main kinds, those employing horizontal hessian cloth "chungs", and those

in which sloping wire netting racks are used. The advantages of the former type are:—

1. Ease of spreading and collecting leaf.
2. Evenness of wither.

These are big advantages, but are offset by the following disadvantages:—

1. Destructibility of the cloth under the influence of rain. The cloth rots if allowed to remain damp for any length of time, and the annual cost of renewal is considerable.

A special kind of hessian cloth can now be obtained, known as "cutched" hessian, which has been treated with a solution of cutch, a substance containing tannin. Cloth so treated does not rot and lasts very much longer than ordinary hessian. Further reference is made to cutched hessian in the paragraphs dealing with bacterial infections in withering.

2. For the same size house, the "chung" type allows of less actual withering space than in the case of racks.

Many people nowadays are converting the sloping wire rack system to a system of flat racks of the same width (about 6 feet) covered with hessian cloth. This system combines the advantage of the wire rack system in saving space, with the advantages, previously mentioned, of the hessian *chung* system.

Wire netting racks have the following advantages:—

1. Although the initial cost is considerable, the life of the wire is many times longer than for hessian cloth.
2. More withering space is obtained by fitting a house out with wire racks than would be the case if the same house had hessian cloth "chungs".

Disadvantages of wire racks :—

1. Spreading and collecting leaf are more difficult operations. In collecting, the racks have to be tapped from underneath to remove the leaf. When leaf is spread, it tends to fall to the middle of the racks where the sag is greatest, thus resulting in uneven spreading, and consequent unevenness in wither.
2. Small shoots and the tips of shoots tend to hang downwards through the interstices of the wire, and to dry up rapidly. This results in loss of tip.
3. It is more difficult to keep the racks free from old leaf and more supervision is required to keep them clean.

The wire in general use is $\frac{1}{2}$ inch mesh wire, a mesh which is much too large. If $\frac{1}{4}$ inch mesh or even smaller were used, all these objections would be to a great extent obviated, since firstly the wire would stand more tension than the larger mesh wire and sagging could be obviated by occasional tightening of the wire. Shoots would not hang through, and in the operation of removing withered leaf, less would be left on the wire to become old and sour. In addition, it is suggested that racks should be somewhat farther apart from each other. Many racks are placed only five or six inches apart and this increases the difficulty of good even spreading. Eight to ten inches spacing makes the work of spreading far easier to do efficiently.

The slope of the racks should be as near to horizontal as possible; in fact it is found in Ceylon that with perfectly horizontal racks there is little difficulty in removing the leaf, and much freer circulation of air over the leaf is possible.

With regard to the speed of wither on hessian cloth as compared to that on wire racks, careful observation has shown that where other factors such as position and construction of house are the same, there is little or no difference in rate of wither.

A very great advance in the practical side of withering would be made if racks could be tilted to a vertical position at the end of withering, so as to allow the leaf to fall to the floor, without the necessity of tapping the wire. This would effect a saving in both labour and in the wear of the racks.

Modern leaf houses are steel frame, built on a cement floor and suitably railed in. The roof is corrugated iron, and the story immediately beneath often attains high temperatures (up to 120°F.). On account of this fact, leaf should only be spread in this story as a last resort when all other available space has been used up. Harm results from withering at abnormally high temperatures. The provision of some sort of sun-proof material for supplementing or replacing corrugated iron would be advantageous though probably expensive.

THICKNESS OF SPREAD

A few figures are here given as to space required according to different standards of spreading. Generally speaking a minimum standard thickness of spreading to aim at is 1 lb. leaf to 1 square yard. If possible during poor withering weather, a thinner spread should be aimed at. Unfortunately poor withering weather often coincides with periods when very large crops are obtained.

The following table gives the area required for a day's spreading on a 10,000 maund crop total, at different thickness of spreading :—

1 lb. leaf spread over.	Square feet space required on average rains day of 80 maunds tea.	Square feet space required for a very big day of 130 maunds tea.
Sq. ft.	Sq. ft.	Sq. ft.
7	179,200	291,200
8	204,800	332,800
9	230,400	374,400
10	256,000	416,000
11	281,600	457,600
12	307,200	499,200

It is not suggested that very heavy days, such as occur only very occasionally, can be arranged for as far

as leaf space is concerned. For 10,000 maunds tea made per season, $2\frac{1}{2}$ to 3 lakhs of square feet of withering space should be a satisfactory equipment.

In North-East India, a good wither is one in which the leaf contains about 65 to 67 per cent of water. Assuming that the fresh leaf contained 75 per cent of water, the above degree of wither is obtained when 100 lb. fresh leaf has dried to 75 lb.

The following table gives the weights to which 100 lb. of leaf should dry in order to contain about 66 per cent of moisture, for leaf at an initial moisture content between 75 and 82 per cent :—

Percentage moisture in fresh leaf.	Lb. of leaf to which 100 lb. fresh leaf should dry.
Per cent.	lb.
74	$76\frac{1}{2}$
75	75
76	72
77	69
78	66
79	63
80	60
81	57
82	54

MOISTURE CONTENT OF LEAF

Unpruned tea especially at the beginning of the season contains least moisture, i.e., 74 to 75 per cent., and the moisture in such leaf seldom rises above 76 per cent. throughout the season. Tippings and leaf from cut back tea contain from 77 to 80 per cent. moisture. Occasionally during the rains when the leaf comes in covered with surface moisture, 81 or 82 per cent. moisture has been obtained. In periods of rapid growth, moisture contents generally rule highest in all types of leaf, while slow grown leaf contains least moisture.

In both Ceylon and Java a much higher degree of wither is aimed at. In the former country the normal wither is called a 55 per cent. one, meaning that 100 lb.

of leaf dry to 55 lb. Assuming that the moisture content of Ceylon fresh leaf is 75 per cent. this average good wither produces leaf containing 54 to 55 per cent. moisture, a much lower figure than that obtained in North-East India.

FACTORS AFFECTING THE WITHER

The rate of escape of moisture from the leaf is dependent on several factors, the chief of which is the drying capacity of the air surrounding the leaf. If the air is in a dry state the wither is rapid, while in the moisture-saturated air, no loss of moisture takes place. A factor influencing the drying capacity of the surrounding air is its temperature. Air raised to a higher temperature has a higher drying capacity than air at a lower temperature, if both contain the same actual amount of moisture per unit volume at the same temperature. Thus temperature indirectly affects the rate of wither. A third factor is the movement of air over the leaf. If the air is still, that layer close to the leaf loses its drying capacity as it takes up moisture, whereas if a fresh supply of dry air is continually in contact with the leaf, the removal of moisture is more rapid. In a similar way the thinner the leaf is spread the more rapid is the loss of water, since a greater surface per pound of leaf is exposed to the drying action of the air.

The rate of withering under constant conditions of temperature and humidity is not steady as one would expect. The rate of wither has been followed, starting at different times of the day, to eliminate variations of temperature and humidity, and it has been found that in a normal 18 hours' wither the leaf loses moisture rapidly for the first four or five hours, then the rate of loss of moisture slows up considerably and becomes constant for the remaining period of the wither. Under factory conditions, where temperature and humidity are not constant, variations in the rate of withering naturally occur. Leaf spread in the afternoon or evening, for instance, loses water rapidly while temperature is high and humidity

fairly low. After sunset, lowering in temperature and increase in relative humidity cause a slowing up in the rate of withering. Unless the leaf is taken off early next morning, rise in temperature and decrease in relative humidity may cause a marked increase in the rate of drying. It thus becomes necessary to watch carefully during the later stages of the wither to see that the leaf does not become too flaccid, or over-withered.

EFFECT OF SIZE OF SHOOT ON RATE OF WITHER

An important observation was made during some experiments on the rate of wither of different types of shoots plucked. The types of shoots and leaves were as follows :—

Bud, first, second, and third leaves and stalk were separated from one another and withered separately. Bud and one leaf, bud and two leaves, bud and three leaves, one *banjhi* leaf and two *banjhi* leaves also were separately withered.

It was found that in each case a perfectly even wither was obtained, though the rates of wither of the different lots compared with each other were very different. The following table gives an idea of the different rates of withering for shoots of different sizes and types. The various types of leaf are arranged in order of the speed of their withering, and opposite each is its moisture content before and after 24 hours' withering.

Type of shoots.	Moisture content of leaf.		
	Fresh leaf.	24 hours' wither.	Difference.
	Per cent.	Per cent.	Per cent.
1 leaf and bud	82·0	47·5	34·5
Small 2 leaves and bud	82·5	60·5	22·5
Large 2 leaves and bud	81·7	60·1	21·6
Single soft *banjhi*	80·0	60·0	20·0
3 leaves and bud	81·0	68·5	12·5
Two *banjhis*	81·5	73·5	8·5
Single hard *banjhi* ...	81·5	73·0	8·5

When a shoot composed of three leaves and a bud is withered the third leaf loses water from its surface less rapidly than the first or second leaf ; yet since water is drawn from it internally by the more rapidly drying first and second leaves, the whole shoot is withered fairly evenly in a normal withering period of 18 to 24 hours. The loss of moisture in 24 hours is however much greater in the case of the sample of two leaves and bud. If therefore a mixed sample of leaf containing both two and a bud together with three and a bud is withered, the former will be ready long before the latter. Since both must in practice be taken up at the same time, an uneven wither is bound to result from mixed leaf.

It is thus clear that in order to get an even wither, the leaf plucked must be as even and as soft as possible, *i.e.*, two leaves and a bud throughout or three leaves and a bud throughout, including only single soft *banjhi* leaves. So long as this evenness is maintained, coarser plucking need not result, as it usually does now, in uneven withering. A very useful check on the evenness of the plucking has been practised on certain Assam estates for some years and consists in separating a fair sample of the day's leaf into the following types :—

Two leaves and a bud.
Three leaves and a bud.
Single soft *banjhi*.
Hard and double *banjhi*.

The four heaps of leaf are counted up and the percentage number of each type of shoot is obtained. After some experience it is easy to define the maximum allowable percentage of the coarser types of shoot which will ensure a reasonably even wither.

The weight of the shoot does not influence its rate of wither to any extent. The following table shows the

rate of withering of two lots of leaf, one of which was composed of shoots twice the weight of the other lot.

Hours of withering.	Percentage moisture content.	
	Large shoots 2 leaves and bud.	Small shoots 2 leaves and bud.
	B	B
	Per cent.	Per cent.
0	79·6	79·2
3	78·0	77·8
6	76·9	76·6
15	73·7	73·2
18	72·4	71·8
21	70·7	70·2
24	68·4	68·3
Total loss in moisture.	11·2	10·9

SYSTEMS OF ARTIFICIAL OR CONTROLLED WITHERING

In certain districts there are times when climatic conditions are such that it is impossible to wither leaf in a reasonable time, i.e., 18 to 24 hours, by merely exposing it, thinly spread, to the atmosphere. If the latter is already saturated or nearly so, it has little or no drying capacity. In order to increase the drying capacity of air two methods are possible: (*a*) to raise its temperature and (*b*) to remove its moisture by passing it over a substance which has the power of absorbing water, e.g., calcium chloride or "silica gel".

Even when withering conditions are what is regarded as good, it is often very difficult to exercise the same degree of control over the withering process that is possible in rolling, fermenting or firing. In Ceylon and Darjeeling, and in parts of the Dooars, withering rooms in which control is possible over the temperature, humidity, and flow of air over the leaf have been in use for many years. In Ceylon and Darjeeling, especially on

high elevation gardens, temperatures are comparatively low throughout the year. Thus when it is required to increase the drying power of saturated air at a temperature of about 70°F. it is a comparatively simple matter to heat the air 5 or 10 degrees, when its drying capacity will be greatly increased and yet it will not be at too high a temperature to harm the leaf. In the plains of North-East India, however, air may be nearly saturated and at a temperature of 85°F. or more. If such air is raised 5 or 10 degrees in temperature, it will of course be much less humid, but its temperature will be such that the leaf on the racks may be adversely affected; for bacterial infection will increase rapidly, especially if the leaf is wet, and dull soft teas may result. Thus the problem of controlled withering is a more difficult one in the plains, and has not yet been employed really successfully to the same extent as in cool high elevation districts.

WITHERING MACHINES

Many attempt to wither leaf artificially and rapidly in machines similar to Endless Chain Tea Driers, or in rotating drums through which warm air is blown, but the temperature of air required to effect such rapid withering is invariably too high for the best results to be obtained.

CEYLON CONTROLLED WITHERING PROCESS

Controlled withering is done in Ceylon and Darjeeling in lofts situated above the factory. Heated air from the drying room, or a mixture of heated air and outside air, is mixed in a central bulking chamber and passed along the lofts over the spread leaf either by booster fans in the bulking chamber or by exhaust fans at the outer ends of the lofts, or by a combination of both.

As the air entering the loft is then at its warmest and driest, the leaf at the bulking chamber end of the lofts, withers most rapidly. The air having absorbed moisture from this leaf loses much of its drying capacity as it passes along the loft and so the leaf at the exhaust

ends might be practically unwithered when the leaf at the opposite end is ready. To obviate this uneveness in withering, a reversible system was evolved and is in use in many factories.

The two diagrams illustrate roughly the working of the system.

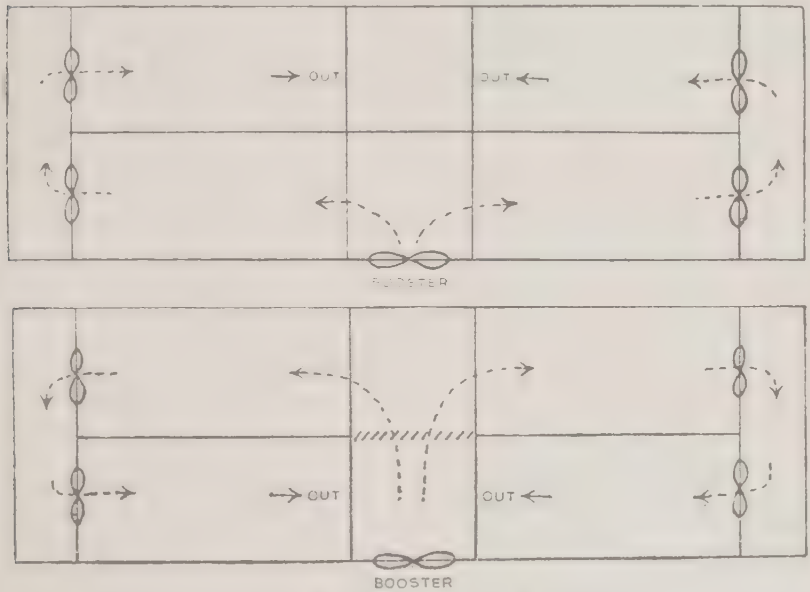


Fig. 15.--Reversible Loft Withering.

In the top diagram the booster fan passes the air through the two lower lofts then into end chambers, and up over the top lofts in the opposite direction. The upper half of the central bulking chamber is separated from the lower by shutters or doors. After a time, as judged by the tea maker, these shutters are opened, the end fans reversed, and air drawn first over the top lofts, then down the end chambers and finally over the lower lofts. In this way an even wither can be obtained. The system is of course equally adaptable to pairs of lofts side by side instead of one over the other. Reversible withering overcomes to a great extent uneven withering of the leaf, but is reported not to be entirely satisfactory in this direction.

OTHER SYSTEMS OF CONTROLLED WITHERING

Variations in the method of driving the air over the leaf have been tried ; and one successful system was worked out by Mr. Bateman, a Dooars planter, which is a successful attempt to overcome the irregular withering resulting from other methods of control. Air from outside is pushed by a fan over a heater outside the withering house, and led through ducts and thence through a grating into the ground floor of the house.

By means of convection the warm air (entering the house at 90 to 100°F.) passes upwards through the successive stories and at the same time exhaust fans in the walls of the ground floor and lofts above remove air which has passed over the racks of leaf. It is claimed that a perfectly even wither can be obtained by this system.

USE OF SILICA GEL

No system of the type described above avoids the objection that air is often already at too high a temperature, during the rains months in the plains of North-East India, to be heated in order to increase its drying capacity. There remains the consideration of methods for removing moisture from the air. At the present time, only one system, and that on one garden only, has been tried out on a practical scale. The withering loft is much the same as that used in the "Ceylon systems" of controlled wither. Outside air is passed through cylinders containing trays of a substance called silica gel, which has the property of absorbing moisture from air. The resulting dry air is mixed in a certain proportion with ordinary air, the proportion depending on the humidity of air required for withering the leaf; and is then passed over the leaf on the racks by a system of booster and exhaust fans. After some use the silica gel loses its power of absorbing moisture and has to be regenerated by heating to a high temperature (300°F. or thereabouts). The system is a beautiful one from an engineering point of view, and produces a good wither under all climatic conditions—in

fact perfect control over the withering process is possible. Objections are however the initial expense, running costs and the need for constant services of an expert electrician to maintain in accurate working condition all the delicate electrical controls of temperature, humidity and flow of the air. All the same, persistent experimentation with this system would probably result in simplification of the process and there is no doubt that if good withering, independent of weather conditions, is desired on plains gardens, a system of this type is the only satisfactory one.

CONTAMINATION OF LEAF DURING WITHERING

Withering is a process which seldom takes less than 8 hours, and usually 18 hours or longer. During this time, given favourable conditions for development, any bacteria present on the leaf before plucking, or picked up between plucking and spreading in the withering house, or existing on the withering surface in contact with the leaf, may develop to an extent at which they may exert a very markedly bad effect on the resulting tea.

Ideal conditions for development of bacteria during withering are: (1) Leaf with surface moisture. (2) High humidity of the atmosphere. (3) High air temperature. (4) Old hessian cloth. (5) Borer droppings from bamboo supports for the hessian cloth.

Humid or moist conditions combined with high temperatures (within certain limits) are in general most favourable to the development of bacteria. Old and partially rotted hessian cloth may be a hotbed for harmful bacteria. Borer droppings from the bamboo supports of hessian cloth have been shown to contain a very high infection of bacteria which affect adversely the quality of tea. It must not be thought that these bacteria are in any way harmful to the human system. They are, in fact, harmless in this direction, being merely of the types which attack organic matter and break it down into simpler substances, just as do the nitrifying bacteria in the soil. Their effect on the desirable characters of

tea may however be very adverse, though they will not in any way render the tea in the slightest degree harmful to the human system. From the point of view of the market value of the tea it is thus of the greatest importance to do everything possible to eliminate bacterial infection of tea leaf in all stages of manufacture. The substitution of wire mesh instead of split bamboos as a support for hessian cloth is the obvious solution of the trouble arising from borer droppings, and this has been done in the majority of gardens which employ hessian cloth withering. The use of "cutched" hessian cloth, on which bacteria do not develop, is the solution to trouble from old rotten hessian cloth of the ordinary type. The cutched cloth is naturally more expensive, but is stronger, and greatly outlasts ordinary hessian.

Wet leaf is undoubtedly a difficult proposition; where controlled withering is installed, its greatest value is in drying off quickly the surface moisture from such leaf, so that conditions favourable to bacterial development are of as short a duration as possible. Where there is no controlled wither system it is a question of whether natural climatic conditions can be expected to effect the drying of surface moisture quickly, or whether, as is often the case in some districts, it is better not to wait in the hope of such favourable conditions but to make the best of things by rolling the leaf before it has even commenced to wither. The latter course will produce tea of the poorest appearance, but liquors will at least be of a useful type, while if wet leaf is left for more than 24 hours to wither, the resulting liquors will be poor even to sourness though appearance of dry tea may be passable or even good.

NO WITHER SYSTEM

The prevalence, in the rains, of poor withering conditions and high temperatures in the Dooars, combined with the frequency of occasions when wet leaf is brought into the factory, has undoubtedly contributed to the success of what is known as the "no wither system" of

manufacture. In this system fresh unwithered leaf is put through a chaff-cutter or a tobacco cutter, and the finely cut leaf is rolled, fermented and fired. A flat, flaky reddish tea is obtained, and the liquors, though generally thin, are brisk and have a distinctive flavour which has been sought after by certain buyers at any rate. Infused leaf is bright and of good colour.

The system has variations, as for example in time of rolling and fermentation. On some gardens the leaf after cutting may be spread on a fermenting floor for 15 to 40 minutes and then rolled for 30 to 60 minutes; then fermented for 20 to 40 minutes and then fired. Other gardens roll immediately after cutting and on one or two gardens a C. T. C. machine supplements the rolling process. Further reference is made in the two subsequent chapters to the "no wither system".

NEED FOR GOOD SUPERVISION IN WITHERING

Good withering requires good supervision, during spreading of the leaf and during the collecting of it from the racks or chungs. In spreading especially, all care should be taken to avoid damage to the leaf, and in collecting attention should be paid particularly to avoiding introduction of foreign matter, and bacterial contamination. The use of bamboo sticks for evening up the spread of the leaf is undesirable as it damages the leaf.

In collecting, leaf should not be swept or shaken from the racks onto the floor, however good a floor it may be. Treading on leaf, so popular a practice among withering house boys, should be strictly forbidden. If possible it should be arranged that only so much leaf as is required to keep the rollers charged is swept off the racks at one time. The piling of leaf in heaps where it may lie for a long time before rolling is most undesirable.

CHAPTER XVI

ROLLING AND FERMENTING

THE rolling room should be situated in a cool part of the factory, away from the direct rays of the sun, and arranged so that windows and doors may be thrown open to let in cool fresh air from verandahs. Shade of some kind will probably be necessary on west and south sides.

COOLNESS

If the rolling room forms a part of the main floor of the factory, in common with the drying room, it is very desirable to have the two departments separated by means of partitions of efficient heat insulating material. Similarly, it is necessary to separate this room from the engine room, or any other place where heat is generated.

BAD ODOURS

All stores of paint or any article of a malodorous nature must be kept quite away from the main factory because tea is peculiarly liable to take up taints from its surroundings, especially during manufacture.

OBJECT OF ROLLING LEAF

The chief purpose of the rolling process is to bruise the cells of the leaf so that their sap is exposed to the action of the oxygen in the air. Rolling also puts a twist to the leaf enabling grades such as orange pekoe and pekoe to be made.

CONTENTS OF THE CELL SAP

The cell sap contains a number of chemical substances mostly of a complex nature, such as tannins, caffeine, protein substances and others. In the processes

to be described tannin plays the most important part, producing as it does those even more complex red and brown substances which give characteristic colour to tea liquor and infused leaf.

TEA-TANNINS

In the green leaf the substances classed as tea-tannins are white substances easily dissolved in water forming colourless solutions with a bitter and astringent taste. Chemists have accumulated much data of importance regarding these substances, but our knowledge is still very far from being complete. We know however one very important fact which cannot be too often or too emphatically stressed. Tea-tannins are of an entirely different nature from the tannins found in the bark of certain plants and employed in the tanning industry. These latter are known as galloyl-tannins and have a peculiar property—that of combining with proteins to form hard insoluble substances. This is the principle behind the tanning process. The galloyl-tannin in the tan liquor combines with the protein in a raw skin or hide soaked in the liquor, and the result is the impregnation of the skin with the insoluble leathery tannin-protein compound, giving it the characteristic properties of leather. Tea-tannin will not tan skins, and moreover is different from ordinary tannin or tannic acid, in its physiological effect on the human system. Tannic acid is constipating whereas tea-tannin has a mildly laxative effect.

Tea-tannins belong to the catechol-tannin group, and during rolling and fermentation they are acted on by enzymes in the leaf and oxygen in the air, to form substances varying in colour from light red to brown, and soluble to varying degrees in water. The more efficient the bruising of the cells of the leaf, the more even the colour of the fermented leaf. Poor rolling results in mixed green and red colours on the leaf. The presence of hard, old, or *banjhi* leaf which does not easily bruise is also responsible for mixed colours of the fermented

leaf and no matter how long fermentation is prolonged, the greenness due to under-rolling or hard leaf can never give place to bright red colour.

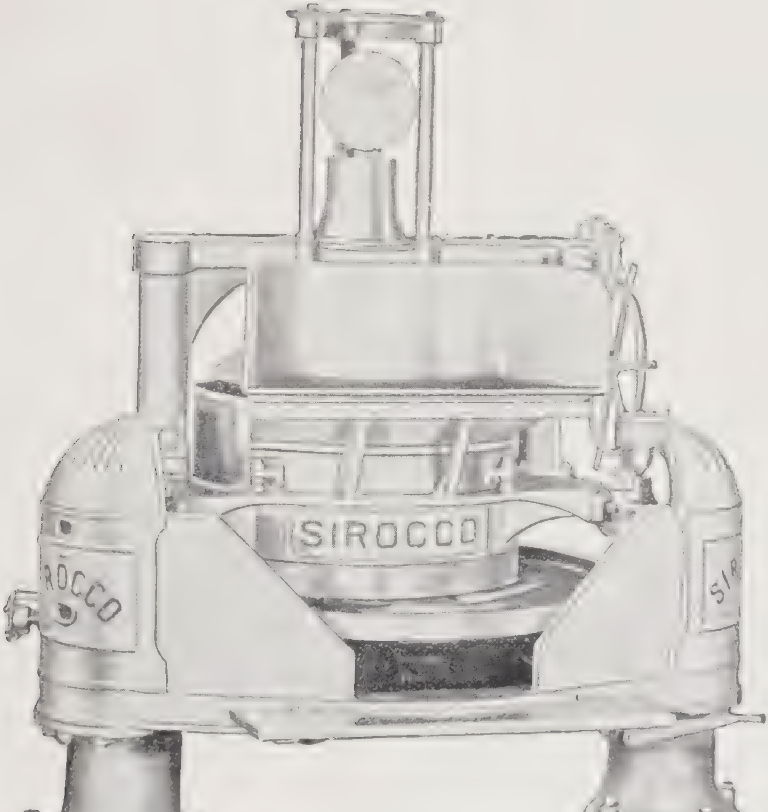
CHARGE ON LEAF IN ROLLERS

It is a great mistake to assume that a roller will roll efficiently as much leaf as can be jammed into it, and that all that is necessary is to get plenty of pressure on the leaf. The large modern roller will not roll any more efficiently than the old type of roller if overloaded, in spite of the size and robust construction of the former, and its formidable array of battens. A charge of 300 lbs. of withered leaf is found to be the maximum which any roller should contain, if rolling is to be efficient. We are referring here to the rolling of withered leaf in particular; not to the rolling of cut fresh leaf in the "no wither" system.

HEATING OF LEAF IN ROLLERS

During rolling heat is developed, firstly from the mechanical energy driving the roller and secondly from the oxidative process going on in the bruised leaf. The atmosphere of the rolling room itself absorbs heat by radiation from the walls and roof, from warmer air entering from outside through windows, doors, etc., and from the heat given out by the bodies of people in the room.

Practically all the horse-power consumed in rolling must be converted into heat and this accounts for the greater part of the heating up of leaf in rollers. With big charges of leaf and hard pressure in rolling, the horse-power required—and consequently the rise in temperature of the leaf—is much greater than with light charges and medium pressure rolling. The frequent raising of pressure caps during hard rolling helps greatly to keep down temperatures, and is also necessary to ensure that the leaf in the roller is turning over properly and not packing into a solid mass.



"Sirocco" 46-6" Senior O. C. B. Roller.

Under poor conditions of rolling, *i.e.*, too large a charge of leaf and insufficient attention to raising and lowering of caps, the leaf may rise as much as 10°F. or more above the room temperature. The latter is often 90°F. or higher in many rolling rooms during the rains so that temperatures of over 100°F. are frequently recorded for leaf when dropped from the roller. It has been shown that this temperature is sufficient to make very poor liquoring teas out of leaf which, under cool rolling and fermenting conditions, would produce really good quality teas.

COMBINED ROLLING AND FERMENTING ROOM

At one time it was always the rule to have the fermenting room entirely separate from the rolling room often in a separate building away from the factory, e.g., forming part of the ground floor of a withering house. Nowadays one sees many factories in which rolling and fermenting rooms are one. This saves much trouble and labour in carting rolled and fermented leaf, but it is often a more difficult task to maintain low temperatures in a combined rolling and fermenting room. Humidifiers, mist chambers and other devices for cooling and humidifying the air are common in modern factories, but unless well designed and intelligently operated, they effect but little cooling, and may result in increased bacterial infection, through maintaining the floors in a continuously wet condition. The problems involved in the use of cooling and humidifying devices are referred to in greater detail later in the chapter.

SYSTEMS OF ROLLING

On Assam gardens generally, and also on some gardens in other districts of North-East India, it is usual to give three rolls, with a green leaf sifting after the first and second rolls. During the second flush period however many gardens confine their rolling to two rolls only.

Where the C. T. C. machine is in use, rolling may be cut down to only one roll, or at most two. Most Dooars and Surma Valley gardens roll only twice but often this is because of insufficient machinery. Certainly gardens which pluck coarse leaf would do well to roll three if not four times in order to bruise the coarser leaf, and so avoid mixed colours of infused leaf.

A suitable (and common) system of rolling in Assam, is three rolls each of 30 minutes' duration, with 10 minutes between each for unloading, *kutcha* sifting and refilling. To carry out this system, the rolling machinery required is reckoned to be one roller for every 900 maunds tea made during the season. Thus a garden making 7,000 maunds tea requires 8 rollers to roll efficiently, and to avoid excessively long factory hours during periods of hign crop production.

ROLLER CAPACITY

Since the allowance is one roller per 900 maunds tea made, and since on an average "big" day in the rains the amount of tea made is about $\frac{3}{4}$ per cent of the total crop under normal pruning and plucking conditions, it will be found that the number of rollers required, is one-thirtieth of the weight in maunds of green leaf brought into the factory on a "big" day. This assumes that 100 lbs. of leaf contains $77\frac{1}{2}$ per cent. moisture. Thus, if the total season's crop is say 9,000 maunds of tea, $\frac{3}{4}$ per cent. of this is $67\frac{1}{2}$ maunds, the quantity made on a big day's manufacture. This is equivalent to 300 maunds of green leaf, so one-thirtieth of 300, or 10 is the number of rollers required.

A suitable rolling system of three half-hour rolls with 10 rollers would be to start four first rolls; kutcha sift and load the coarse leaf from this kutcha sift into three rollers for second rolling; kutcha sift again, and load the coarse leaf from the second kutcha sift again into three rollers for the third roll. Assuming that 20 per cent. of the leaf is taken out as fine leaf from each

kutcha sift, and no roller is to be charged with more than 300 lbs. of withered leaf, the charge required will be as follows:—

4 charges of 280 lbs. each for the first roll = 1,120 lbs. withered leaf.

20 per cent. removed in first kutcha sift = 224 lbs. leaving 896 lbs. to be divided between three second rolls, giving about 300 lbs. per roll.

Again taking out 20 per cent. from the second kutcha sift (180 lbs. leaf), about 720 lbs. is left for three third rolls, or 240 lbs. per roll.

Assuming 10 minutes to be the time taken for emptying the rollers and refilling them, one batch of four first rollers delivers at the rate of 1,120 lbs. of withered leaf per 40 minutes, and this governs the output of leaf from the fermenting room to the driers. Thus there must be sufficient drying machinery to take 1,680 lbs. withered leaf per hour. This means that the output of the driers must be approximately 7 maunds fired tea per hour, as a minimum.

As regards the hours of rolling on a big day; a crop of 67½ maunds tea, at the rate of 7 maunds per hour, requires nearly 10 hours rolling time.

Similar rolling systems may be worked out for all sizes of crop, and an estimate made of the numbers of rollers, size of fermenting space, and drying equipment required. Figures will of course vary with wide limits according to the number and length of rolls, and whether or not a C. T. C. machine is used.

In many factories, unfortunately, there is not only shortage of machinery to manufacture the crop under the best conditions, but often the machinery equipment is badly balanced. For example a factory may have ample rolling machinery, but insufficient firing machinery to deal with the output of fermented leaf when the rollers are working under optimum conditions.

PRESSURE IN FIRST ROLL

Modern rollers are fitted with pressure caps loaded with springs which enable tremendous pressure to be exerted on the leaf during rolling. It is usually the practice not to put pressure on the leaf during the first roll, or at any rate, to apply only very light pressure, unless the leaf is very over-withered. In many factories rollers used for the first roll have no pressure caps at all. In others the box is often built up with wood so that a larger charge of leaf can be laoded into the machine. This is not considered a good practice and is seen to a much less extent now than formerly. The best results are obtained from a normal charge of 240 to 300 lbs. withered leaf, with just efficient pressure, according to the degree of wither, to express a little juice,—enough only to cover the surface of the leaf and soak the buds. Unless the silvery hairs on the buds are soaked in juice they maintain their silvery hue and do not assume the golden colour which is so desirable. An indication that the correct pressure is being applied is the appearance of a few flakes of foam oozing from the door of the roller, towards the end of the first roll.

ROLLING OF OVER-WITHERED LEAF

Over-withered leaf gives little or no juice; in fact it often happens that the leaf is so dry that there is insufficient juice expressed in the first roll even to cover the buds and produce golden tip. The result of an over-wither is therefore often a silvery tip. Some planters add water to the leaf in the first roll and this is not a bad plan provided the water is clean, not alkaline, and free from bacteria. A simple calculation will enable one to estimate the amount of water required. For example, supposing the leaf has withered to the extent that 100 lbs. fresh leaf has produced only 50 lbs. withered leaf. A wither of 100 lbs. fresh leaf to 60 lbs. withered leaf would have given leaf which would roll satisfactorily. Therefore for every 50 lbs. of over-withered leaf 10 lbs. or 1 gallon of water should be added. Thus to make

the total charge in the first roll up to 300 lbs. leaf, there will have to be 250 lbs. of the over-withered leaf, and 5 gallons water. This should not be added all at once but gradually, over a period of about 10 minutes, after the rolling has been going for about 5 or 10 minutes, when the leaf is then better able to absorb the water. If added all at once at the start of the roll, much water will run out at the bottom of the roller.

PRESSURE IN SECOND AND THIRD ROLLS

In the second and third rolls, after the tender leaf and buds have been removed by sifting, the coarser leaf needs some considerable pressure to assist in bruising its cells. For the second roll, periods of 5 minutes with the pressure cap down so as to give medium pressure, alternating with 5 minute periods of no pressure, is a common system. In the third roll it is common to have 5 or 7 minute periods of hard pressure with 5 minute intervening periods of no pressure.

JUICE FROM UNDER-WITHERED LEAF

Juice is often expressed, especially if the leaf is poorly withered. Although this juice contains soluble substances which to some extent might improve the strength of liquors, it is the usual practice to discard this juice, which runs out of the bottom of the roller into the trolley or box beneath. Sometimes it is left in the trolley till the end of the roll and the leaf dropped into it and allowed to absorb the juice.

There are however objections to this; firstly the extra coal consumption required in the driers to remove this excess moisture and secondly the risk of stewing or bad firing of the over-wet fermented leaf. If there is only a small amount of juice, as in the case of hard rolling on well-withered leaf, there is no objection to retaining this juice and allowing it to be mixed with the rolled leaf.

Much care is needed to avoid over-withered leaf (*a*) by taking the leaf from the more rapid-withering

parts of the withering houses for the first rolls of the day, and (*b*) when spreading the fresh leaf, to spread part of it slightly more thickly than the remainder so that it may be kept safely for the later rolls without becoming over-withered. In some factories, to avoid over-withered leaf, the air in the withering house is sprayed with clean water from garden sprayers or syringes. Care is taken not to spray the leaf itself.

BATTENS ON ROLLERS

Modern rollers are usually provided with brass battens on the table, which is dish-shaped, with the object of increasing the cutting up of the leaf, the bruising of the cells, and the turning over of the leaf in the roller. These battens are shaped rather like a boomerang and fastened in spiral formation, and the thicker ends towards the centre of the table. The roller is designed to rotate in one direction only, otherwise if going the opposite way the battens tend to throw the leaf to the outer rim of the table. The direction of rotation of the box in a double action roller is normally clockwise, and that of the table counterclockwise. This puts a clockwise spiral twist on the leaf. It is commonly believed that if a first roller is going one way round and the second roller in the opposite direction, the twist of the first roll is undone in the second roll, and for this reason it is considered advisable to have all rollers revolving in the same direction.

SPEED OF ROLLING

Rollers usually run at speeds of 50 to 70 r.p.m. in North-East Indian tea factories, though some gardens run them faster with satisfactory results. In Ceylon rolling is generally slower, but in this case rolling is usually for a much longer time. It is not uncommon in Ceylon to do 5 or even 6 rolls of 30 minutes each, the rollers running at not more than 40 r.p.m. Slow rolling gives a good twist, but unless time of rolling is proportionately

lengthened, less bruising of the leaf is obtained. This may result in greener infused leaf and thinner liquors.

Fast rolling, especially with under-withered leaf, may cause loss of appearance and tip, though liquors may be stronger.

KUTCHA, OR GREEN LEAF, SIFTING

After the first roll the leaf is sifted through a mesh which commonly varies between No. 3 and No. 4, in order to take out the tip and small leaf, which forms the "orange" grades. The machines for this sifting are of two main types, rotary and flat. Each type has its advantages and disadvantages. The rotary type if properly constructed and running at the right speed gives very good sifting and cools the leaf better than the average flat type of sifter, but in general the flat type is much easier to keep clean than the rotary type.

ROTARY KUTCHA SIFTERS

The rotary type should be constructed of 4, 5 or 6 sides; round or 8 sided machines do not seem to sift so well as those of not more than 6 sides, and the mesh tends to get more clogged with leaf. A very good type of machine with 4 or 5 sides can be made so that it is easy to clean, by having the sides constructed as separate and easily removable frames. With a spare set of frames for each kutcha sifter, there is no difficulty in maintaining a scrupulous cleanliness of the mesh, since one set can be taken away and cleaned while the other set is being used. The sets should be changed over at intervals of not more than 4 rolls, especially during the time when the leaf is very wet, and conditions are most favourable for bacterial infection.

FLAT KUTCHA SIFTERS

These are frequently compared unfavourably with the rotary type, but if constructed properly and run at the right speed, the flat type can be made to do the job perfectly. There is often, unfortunately, a tendency to

imagine that the faster a machine runs and the greater the quantity of material it is dealing with, the more efficiently it is working. This is certainly not true of the majority of flat kutcha sifters in use in North-East India. The slope of the mesh is frequently too great, and though it is possible to pass a large quantity of leaf per minute over the machine, the sifting out of the fine "mal" is often hopelessly inefficient. The leaf after falling on the mesh at the top of the slope is often observed to bounce about twice on the mesh before it is thrown off at the lower end. The result is that if the correct mesh for taking out fine mal after the first roll (No. $3\frac{1}{2}$ or 4) is used, very little fine mal comes out. To rectify this, a larger mesh, often No. 2 or $2\frac{1}{2}$, is used. This results of course in an increase of so-called fine mal, but actually much of this is coarse and requires more rolling, which it does not get. The result is the familiar "mixed infusion", and often, thin liquors in the orange grades.

The best type of flat sifter is the Java type; in which the feed hopper is actually lower than the outlet, and the leaf is made to travel upwards over the mesh. It thus takes longer to pass over the mesh than in the type of sifter commonly used in India, and a much more efficient sifting of fine mal results. In this machine the cooling of the leaf is equally as good as in the rotary type of sifter.

With efficient sifting and rolling 20 per cent is the maximum quantity of fine mal which should be extracted after the first roll. More often the percentage is nearer 15 per cent, while after the second roll, up to 25 per cent may be removed. The removal of larger percentages than these indicates that a certain amount of coarse leaf is being extracted along with the fine, and the result may be as previously stated—deterioration of infused leaf and liquors.

FERMENTATION

The leaf after rolling and sifting needs to be fermented for a period which depends on wither, temperature

and the amount of rolling it has undergone. As a general rule, taking the time from when the first roll starts, it is usual to ferment for a period varying between $2\frac{1}{2}$ and $4\frac{1}{2}$ hours. Assam second flush leaf appears to ferment rapidly, and is usually given $2\frac{1}{2}$ to 3 hours; rains leaf 3 to $3\frac{1}{2}$ hours and autumnal leaf $3\frac{1}{2}$ to $4\frac{1}{2}$ hours. There is a tendency to over-ferment in many factories due to the fact that through inefficient rolling or presence of coarse and banjhi leaf, the fermenting "mal" shows a good deal of greenish leaf. This leaf however remains green because it has not been bruised, so that prolonging the fermentation is unlikely to redden such leaf, and the properly bruised leaf meanwhile becomes over-fermented. Mixed colours of infusions are generally due to presence of coarse and banjhi leaf, or to inefficient rolling or sifting.

Time of fermentation is affected by temperature, the higher the temperature the more rapid the fermentation. Provided the leaf is properly rolled, a good wither gives a more rapid fermentation than a kutcha wither.

THICKNESS OF SPREAD

The general practice nowadays is to spread the leaf fairly thinly for fermentation, i.e., one to one and a half inches thick, on a cement floor or on some other surface which can easily be kept clean. Thick spreading results in heating up of the leaf, and as coolness is essential to good fermentation, thick spreading should be avoided.

"RUNG" ROLL

In a few gardens a short roll is given to the coarse leaf after fermentation, before the leaf goes into the drier. The object is to improve the twist on leaf which is thought to have become partly untwisted when lying on the fermenting floor, or during the kutcha sifting. Unless rolling prior to fermentation has been very inadequate it is unlikely however that the "rung" roll is of any material benefit.

FERMENTING SURFACES

A really good cement floor is an excellent surface for fermentation. A bad floor, i.e., one which is cracked or porous, is a natural breeding place for bacteria which have a harmful effect on tea, and is extremely difficult to maintain in a clean condition. In many factories floors of glazed tiles or slabs of glass are used. These may be quite satisfactory, but care is needed to keep stale leaf and juice from lodging in the cracks between the tiles or slabs. Other factories use sheets of aluminium, the surface of which is easy to keep clean. One objection to aluminium is that it does not conduct heat away quickly, and leaf on aluminium, especially if spread thickly, heats up more than on a cement surface. This objection can however be overcome by painting the underside of the sheets with a dull black paint.

A satisfactory type of fermenting bed is that in which reinforced cement slabs are built in tiers of three, with a space of about two feet between them. They may be made with a slight slope in either direction from the centre and a convenient width is 6 feet; see Fig. 16.

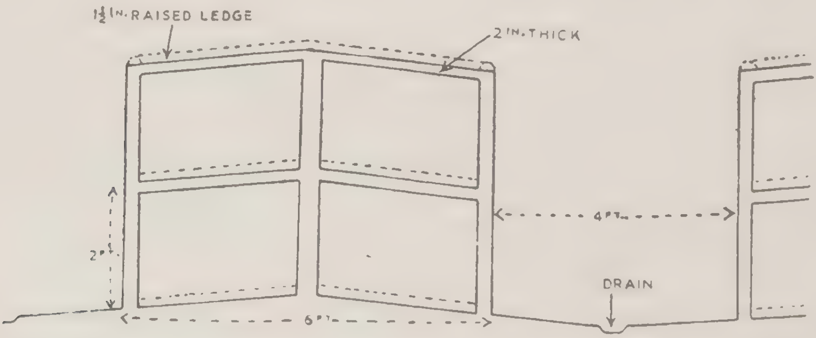


Fig. 16.—Reinforced Concrete Fermenting Beds.

The slabs are of a good concrete mixture, surfaced with cement or Indian patent stone, and the reinforcing of stout rabbit wire or expanded metal. A raised ledge, about 1½ inches high (shown by dotted lines in the diagram), helps to avoid leaf falling on the floor and acts as a gauge for thickness of spread. A similar

system, using aluminium sheet trays, can also be used, and here all that is required is a light frame of angle iron to support the trays.

TEMPERATURE OF ROLLING AND FERMENTING

Experiments have shown that it is of the utmost importance to keep the leaf as cool as possible during rolling and fermentation. In fact it is very possible that the optimum temperature for these processes may be much below what is at present considered quite satisfactory—in other words, well below 75 or 80°F. To maintain such low temperatures in factories in North-East India would involve the use of air conditioning and refrigerating plants. In such a case, the design of rolling and fermenting rooms will have to be considerably modified.

Much can be done, however, without a refrigerating plant, to maintain a supply of cool fresh air, and reduce the temperature considerably below what is at present a common figure in the rains, i.e. 90°F. or over.

Firstly the design and ventilation of the room is of importance—rolling rooms especially are generally in need of much improvement in these respects. Reference is made to structural design, heat insulation and ventilation in the chapter on Buildings and Machinery.

HUMIDIFIERS

In many factories humidifiers or mist chambers are installed in rolling or fermenting rooms, or in both. There are several types of humidifiers, of which the commonest in tea is probably the "Vortex". The principle is that a fine spray of water is forced through a nozzle, and forms a mist in the atmosphere (excess water being trapped and removed) so that the atmosphere is humidified and at the same time cooled. The extent of the cooling depends on the original dryness of the air—if very dry the cooling is considerable, but if already saturated with water, no cooling results. Thus humidifiers are of great value in cooling down a room

during the early part of the season and during dry spells in the rains, but are of little use in this respect in very humid weather.

Care must be taken also, to prevent the deposition of water on the floor and leaf beneath the humidifiers; by running them for short periods at a time, and stopping whenever the floor underneath begins to get wet. The water used in humidifiers should be bacterially clean, and should not contain more than about one-tenth of a grain of iron per gallon of water. Some waters, especially from tube wells, often contain much more iron than this.

MIST CHAMBERS

The mist chamber is a room or part of the rolling or fermenting room partitioned off, through which air is passed by fans. The chamber is fitted with pipes and nozzles through which water is sprayed in a fine spray, humidifying and cooling the air. Excess water is removed by suitable baffles; the cooled and humid air is passed out of the chamber and through the rolling or fermenting room. Exhaust fans are required to assist the flow of air. As in the case of humidifiers, mist chambers can be very useful especially in hot dry weather, in lowering rolling and fermentation temperatures.

LIGHT AND FERMENTATION

It used to be thought that light was harmful to good fermentation, and many fermenting rooms were kept very dark, or provided with red glass to the windows. It is now known that light itself is not harmful—in fact so long as it does not result in letting the sun's rays directly into the room, and so causing rise in temperature, the lighter the room the better. In a well-lighted room work can be done better and supervised more efficiently. It is also easier to detect bad parts of the floor and accumulations of stale leaf and juice.

CLEANLINESS IN ROLLING AND FERMENTATION

It has been amply demonstrated that the best teas are made when conditions of rolling and fermenting are scrupulously clean. Stale leaf or juice is an ideal medium for the development of certain types of micro-organisms which, if allowed to develop, may result in serious harm being done to the tea.

TEST FOR BACTERIAL INFECTION

A simple test devised by the bacteriologist to the Indian Tea Association, which may be carried out in any factory, and in fact should be regarded as a routine test will indicate whether conditions are satisfactory in regard to bacterial infection. It consists simply in taking a few ounces of leaf from a roll towards the end of the days's manufacture, placing it in a glass or glazed dish, and covering it with a piece of glass. The sample is examined after 12 or 18 hours. The leaf should then have the same small as ordinary fermented leaf, except possibly for a slight sweet or fruity odour. It should not feel slimy to the touch and the colour should still be bright, not chocolate coloured or dark. If this leaf is infused the liquor should be fairly bright and free from sediment, though it may be slightly cloudy. With milk it should not be coffee coloured but a bright orange red colour. The undesirable characters referred to above are the result of infection by bacteria during manufacture. Where the infection occurs in the factory is of course a matter for further investigation.

CLEANING OF ROLLERS, SIFTERS, ETC.

Rollers, sifters and leaf trolleys need constant attention to maintain them in a sterile condition. There are so many cracks and crevices where leaf and juice may lodge that the mere washing down daily with water is not sufficient to remove such debris. Steam or high pressure water is a great boon, and wire brushes for cleaning the mesh of sifters are essential.

Blow lamps are extremely valuable for charring deposits of juice and leaf, enabling them to be easily removable by a brush, and at the same time destroying bacteria present. Care is necessary however to see that the flame of the blow-lamp does not play for long enough on a surface of mesh to raise the metal to red heat, otherwise the galvanizing is burnt off and also the temper of the wire is lost.

Cracks and crevices in rolling tables and in leaf trolleys should if possible be sealed by brazing if the material is brass. Hard bitumen is also useful for this purpose, the sheets of brass being removed from the table, molten bitumen poured onto the foundation of the table, and the brass sheets made hot and screwed down tightly. The table is left for a day for the bitumen to harden, when the excess which has squeezed through the joints of the brass may be chiselled off flush with the surface. A good hard bitumen does no harm to the leaf with which it comes into contact. Bitumen may also be used for filling hollow battens on rolling tables. All wood, e.g., wooden roller caps, should be kept from contact with leaf and juice, by facing the wood with brass sheet, or better still replacing entirely by metal.

It is best to wash and scrub down thoroughly at the end of the day's work and to use the blow-lamp next morning before manufacture, when the machinery is dry.

The old method of carrying "rung" or fermented leaf in bamboo or cane baskets and wooden trolleys has now, happily, been superseded by the use of aluminium bowls and trolleys. The baskets were an extremely fertile source of infection as it was impossible to clean them, whereas the cleaning of aluminium bowls and trolleys is simplicity itself.

ROLLING ROOM FLOORS

Efficient drainage, particularly of rolling room floors, is essential as often much juice comes out of the rollers and must be got rid of in order to prevent it becoming a source of infection. The slope of the floor

under rollers should be from front to rear, enabling juice and bits of leaf to be washed into a drain running behind the line of rollers. Squeegees of stout rubber sheet may be used effectively for removing excess water after washing down. If suitable trolleys are used and charges of leaf in the rollers are not excessive it should be possible to drop the leaf from a roll straight into the trolley underneath so that little or none drops onto the floor. It is safest to discard leaf falling onto the floor under the rollers, particularly if the floor is a poor one. If the floor is good, a certain area under each roller should be marked off and kept scrupulously clean, so that leaf falling within this area need not be discarded.

A similar plan may be adopted with kutcha sifters, a certain area of floor being marked off and kept clean. In many factories the floor under kutcha sifters is covered with aluminium sheets onto which the leaf is allowed to drop. The coarse leaf from the outlet should be collected in a receptacle of suitable size and shape so that as little as possible spills over onto the floor. This not only reduces risk of infection, but saves the labour of gathering up the spilt leaf.

Much care is required in filling rollers with leaf, to avoid scattering it over the floor, on which it may be trampled. Small baskets for charging first rollers with withered leaf, and small bowls for filling second and third rollers with "rung" are preferable to large receptacles.

FERMENTING SURFACES

When rolled leaf is placed on a fermenting surface, some of the juice inevitably is transferred to that surface, and remains when the leaf is lifted for firing. The deposit of juice may if left undisturbed become quite thick, especially on a rough porous surface. This film of juice offers a good opportunity for bacteria to breed, especially under damp humid conditions. Apart from the effect of direct contact of this layer of juice with fresh fermenting leaf laid on the surface, there is another, and probably more serious effect. The bacteria decompose

the organic matter in the stale juice and set free ammonia, which penetrates the fermenting leaf, and owing to its alkaline nature causes the formation of dark brown substances. Anyone who has tried the experiment of adding minute quantity of any alkaline substance such as ammonia, lime, or caustic soda to a tea liquor will realize how ammonia-producing bacteria on the fermenting floor can seriously affect the liquors and infusions of tea.

It is of greatest importance therefore to see that the fermenting surface is kept free from deposits of stale juice. If the surface is aluminium, well laid glass or tiles, really good cement or Indian patent stone, it is no difficult task to maintain it free from deposit. A good scrub down daily after manufacture, possibly in the case of cement or patent stone with the additional use of fine grade carborundum bricks, is all that should be needed if the work is properly done.

USE OF E. C. SOLUTION

A good cement or patent stone surface which has been allowed to accumulate a deposit may need the application of some softening agent before the deposit can be easily removed. E. C. (electrolytic chlorine) solution has the property of decomposing organic matter and may safely be used for the purpose of softening deposits on fermenting surfaces if used properly. The method advised is as follows: Four ounces of 1 per cent solution is mixed with one gallon of water and sufficient sulphuric acid (battery acid) is added with constant stirring until the solution just turns blue litmus red. It will be found that the quantity of acid required is not more than one-eighth of an ounce per gallon of solution. E. C. can also be obtained in 4 per cent and 6 per cent. strengths and the quantity required is proportionately smaller than that in the case of the 1 per cent solution. For the 4 per cent E. C., one ounce per gallon, and for the 6 per cent E. C., two-thirds of an ounce per gallon are the proportions.

The solution should then be poured over the

menting surface and well scrubbed in with brushes or coco-nut husks, together with a little sand. Continued scrubbing, with further addition of E. C., if necessary, is maintained until a clean surface has been obtained, after which the dirt and remaining solution is thoroughly washed off with plenty of clean water.

If the surface of the floor is a poor one, i.e., cracked, rough and porous, it is quite obvious it cannot be properly cleaned in the above manner. Some dirt will inevitably remain in cracks, etc., and having been acted on and partially decomposed by the E. C., is likely to be as bad as, if not worse than it was before, from the point of view of its ability to breed bacteria. A really bad floor should be left well alone, and kept as dry as possible if it has to be used for fermenting purposes. The only real remedy is replacement by a good cement surface, or the use of aluminium sheets.

Another substance which is as good if not better than E. C., for softening deposits of juice on floors, is tri-sodium phosphate, sold in solution under the trade names of "Tepalin" or "Jadoo". This should be made up in hot water, $\frac{1}{2}$ to 1 ounce to the gallon, and used in exactly the same way as E. C. It is alkaline and should therefore be carefully washed off the floor when the juice deposit has been scrubbed away.

C. T. C. MANUFACTURE

A variation of the time-honoured system of bruising leaf in rollers was introduced some years ago by the late Sir W. G. McKercher who invented a machine called the C. T. C. (Crushing, Tearing and Curling) machine for obtaining a better bruising effect on the leaf and for reducing its size before firing. In this machine two parallel stainless steel rollers revolve inwards at different speeds. The rollers are 3 feet long and about 6 inches in diameter and are grooved concentrically and spirally. The concentric grooves of one roller can be made to intermesh with those of the other to varying degrees and leaf is fed in between the rollers and "mangled".

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The amount of bruising, tearing, etc., depends partly on the distance apart of the rollers, and partly on the difference in their speeds. The machine if used properly is capable of making excellent teas, and the rolling time is considerably reduced. For instance, a typical system of manufacture using a C. T. C. machine might be as follows: First the withered leaf is rolled for 40 minutes with light, or no pressure. It is then sifted and the fine leaf separated. The coarse leaf is then passed through the C. T. C. machine two, three, or even four times, sifting out fine leaf after each cutting in the C. T. C. As it takes only a matter of minutes to pass a roll of leaf through the machine, the time which the leaf spends in the rolling room is reduced considerably, and furthermore the only period when the leaf may become unduly heated is during the 40-minute roll.

Systems of C. T. C. manufacture vary considerably and it is impossible to lay down any precise rules for the use of the machine. The gap between the rollers found most suitable for general use is one which just allows a piece of 18 gauge wire to be pushed through. This constitutes also a good means of testing whether the gap is the same at both ends of the rollers. The speed of the slow roller commonly varies from 50 to 150 r.p.m., and that of the fast roller, from 200 to 600 r.p.m.

"NO WITHER" SYSTEM OF MANUFACTURE

In the chapter on withering, reference was made to a system of manufacture which has become very popular in the Dooars and Surma Valley of recent years. In this system the leaf straight from the plucking baskets is fed through a chaff cutter or a tobacco cutter adjusted to give a coarse cut. The cut leaf is then rolled in a roller which has been modified in certain particulars. Battens on the table and the underside of the cap are generally removed and replaced by a boss of wood either on the cap, or on the upper surface of the door, or on both. The edge of the box is fitted with a device for preventing the small leaf from escaping under its edge and being

thrown out. Rolling is generally fairly slow, not more than 50 r.p.m., and only moderate pressure is applied. After rolling the leaf is sifted and balls broken up and may then be fermented straightaway; or the coarse "mal" may be rolled again, or put through a C. T. C. machine.

Fermentation is normally much shorter than in the case of ordinary manufacture. Since the leaf contains practically its full moisture content of 75 per cent at the end of fermentation, firing needs to be carefully done. Firing of unwithered leaf is referred to in the following chapter on Firing.

In some factories the cut leaf is spread two or three inches deep on a fermenting floor for 20 minutes or so before rolling; this being considered to develop an aroma. In some factories also, the leaf is partly withered; or withered and unwithered leaf is mixed. There are many other variations also which have been tried in this system of manufacture.

CHAPTER XVII

FIRING

CHINESE METHOD

FIRING or drying by the old Chinese method of charcoal "chulas" has become so completely obsolete that it is hardly necessary to refer to it here except from the point of view of historical interest. In some factories for many years there was great reluctance to adopt machinery for this process.

CHARCOAL FUMES

It was supposed that the direct fumes of charcoal were necessary to the proper development of flavour, and even after machinery had been adopted, it was for years only made partial use of, all the drying being finished on open charcoal fires.

SAVING OF LABOUR

The saving of labour which was effected by the introduction of drying machines was perhaps not so great as in rolling. A large machine, however, does the work that used to require 30 or 40 men firing tea in the old charcoal "chulas". The best class of drying machines are very expensive; but they do the work very efficiently, and when properly worked are capable of producing just as good if not better teas than the old method.

COMPARISON OF MACHINES

There are several kinds of machines in use, and great differences of opinion as to their respective merits; each has its own advantages; and any one of them is an immense improvement on the old laborious and

unwholesome method. The various types of machine in use to-day are referred to in the chapter on Machinery. The old "exhaust" type of drier is now obsolete having given place to the "pressure" type. Several of the old type can, it is true, be seen working in factories but generally they have been converted by structural alterations, so that they work on the pressure system.

POSITION OF MACHINES

Drying machines are frequently placed so that the stoking of the stove may be done in a verandah outside the main factory and this has the advantage of cleanliness. Moreover, a fresh supply of air from outside is desirable since the air in the drying room, although warmer than the outside air, may be highly charged with moisture taken from the leaf in the driers, and its drying capacity much reduced thereby.

DRAUGHTS

Each machine has to be placed so that no draught from a door or window will affect the air tubes of one side more than those of the other. An open door directly opposite one set of tubes can make a difference of twenty degrees of temperature on one side of the machine compared to the other, because the fan naturally draws its air from the readiest or easiest source, and the heat carried through is proportionately irregular. Every machine requires a thermometer at both sides, in order to indicate at all times whether heat is being applied evenly.

OBJECTS OF DRYING

The first object of the drying machine is to arrest fermentation, and then to slowly desiccate the leaf in such a way as to extract the moisture without scorching the tea, but at the same time preserving quality,, briskness and other desirable characters to the fullest extent.

It is general practice to fire tea in two operations, the first firing being usually done in a machine of the Endless Chain type, and the second firing in a machine of the tilting tray or "Venetian" pattern.

FIRST FIRING

In drying a body such as a piece of tea it is necessary to avoid too rapid evaporation of moisture, since if the surface dries out quickly a hard casing is formed through which the moisture still inside cannot easily escape. It is therefore better to subject the leaf first to somewhat moist air, at a sufficient temperature to inactivate the fermentation enzymes. This arrests fermentation, the temperature required being about 150°F. and possibly rather less in a blast of air. If the temperature at the top of a drier is too low, stewed flat teas may result. The leaf as it passes through the drier in first firing should lose moisture steadily until it is discharged.

Tea leaf normally has a moisture content of 60 to 70 per cent when it enters the drier and should come out with a moisture content of not more than 20 to 25 per cent, which is about what is regarded as equivalent to a "12 anna" fire. Some planters prefer to bring the tea out at a lower moisture content; this often involves raising the firing temperature, and also sometimes results in the tea being overdried in the second firing, with consequent loss of briskness and quality. It is better, however, to bring the tea out drier than 12 annas rather than moister, as the latter generally means that the tea is stewed.

FEEDING THE MACHINE

As short a period as possible should elapse between the time the fermented leaf is taken from the fermenting room and the time it passes over the top tray of the drier. Leaf should not be heaped up behind the spreader of the machine, or kept waiting in baskets in the drying room. The supply of leaf from the fermenting room

should be regulated so as to keep the drier full and no more. The spreaders of many driers run much too fast and throw the leaf into the air. To avoid this, spreaders should be adjusted to make not more than one revolution per second.

TEMPERATURE

The important temperature is that between the top and second trays. This should be kept always as close to 140°F. as possible. If the thermometer is between the second and third trays the temperature should be 150°F. A sufficiently high inlet temperature must be maintained to keep the temperature at the top of the machine steady at its correct figure. With ordinary well withered leaf and a thin spread, the inlet temperature need not be above 190°F. but should not be less than 180°F. The poorer the wither, the higher must the inlet temperature be to maintain 140°F. below the top tray.

FAN SPEEDS

These should be maintained at the figures recommended by the makers. If too low then abnormally high inlet temperatures are required to keep the top temperature to its correct figure, or else stewing may occur through the saturated air near the top of the machine not getting away fast enough.

Fan speeds for machines commonly used for first firing are 450 r.p.m. for "Empire" driers, and 380 r.p.m. for E.C.P's; these are considered to be quite satisfactory, though good results have been claimed for higher speeds than these.

THICKNESS OF SPEED AND SPEED OF TRAYS

The leaf should be spread as thinly as possible particularly when a full wither has not been obtained. The teeth of the spreader should just clear the ribs of the trays. The best tray speed is generally considered to

be the second fastest, the leaf at this speed taking about 20 minutes to pass through the machine.

DEGREE OF DRYNESS AFTER FIRST FIRE

With the above conditions adjusted correctly the 4 and 6 feet machines of both E. C. P. and Empire will turn out 12 annas fired tea, such tea containing not more than 25 per cent moisture. It is *important that tea shall not come out less than 12 annas fired from the first machine.*

SINGLE FIRING

Firing in one operation is preferred by some tea makers, but is less economical and there is risk that under inadequate supervision, some tea may come out less than fully fired. Such tea may go mouldy and taint the rest of the bulk, if not refired quickly.

Tea after first firing should go through the second firing as soon as possible. If it has to lie about, it should not be left in heaps or in boxes as under these conditions it is liable to stew and give soft dull liquors. It should be spread out preferably on a raised wood floor and any steam allowed to escape freely from the bulk.

SECOND FIRING

The inlet temperature for second firing should be kept as close as possible to 180°F. The top tray temperature is of no account in second firing. The firing should be as quick as practicable. Thin spreading, while desirable, is not of such importance as in first firing.

Fine tea or "*dol guri*" which drops through the trays and collects in the bottom of the driers should be removed, both in first and second firing, at least every half hour. Prolonged heating has a detrimental effect on tea. Modern driers have an arrangement fitted for removing automatically the fine leaf falling to the bottom of the machine.

STOKING OF DRIERS

Uneven temperatures and high fuel consumption may result from bad stoking. The temperature of the flue gases passing up the chimney should not be above 400°F. If chimney temperatures are much higher, heat which should be absorbed in the tubes is being lost up the chimney.

LAGGING OF DRYERS

By insulating the stove and ducts of a drier much economy in fuel can be effected. Lagging may take the form of insulating material in contact with the stove parts; or a wall of brick or insulating material may be erected round the stove and 6 inches to 1 foot away with suitable doors for inspection, and apertures for air drawn across the tubes by the fan.

FUEL ECONOMIZER

In addition to saving of fuel by the proper insulation of drier stoves, further considerable saving can, at any rate with the older types of driers, be effected by the use of a fuel economizer, such as has been designed and patented by Mr. M. Baldwin. The principle is briefly to by-pass the hot flue gases from the stove (before they pass up the chimney) through suitably placed tubes or through a chamber fitted with air tubes, so that the air going into the stove of the drier is first made to absorb the heat of the flue gases. In the case of one type of machine the flue gases are by-passed through flues running along both sides of the stove just above ground level so that fresh air entering the stove must pass over, and absorb, what would otherwise be waste heat. In another type of drier the chimney at the back of the stove is removed and gases are passed through two flue boxes and thence by underground duct to an outside chimney. The flue boxes have 6-inch pipes open at both ends running from front to rear; the front end is flush with the stove doors; and the rear end a few inches from

the air inlets to the drier stove. Thus the intake air for the drier passes through the tubes in the economizer flue box and is preheated. The inventor claims a minimum saving of 25 per cent in fuel by the use of these devices, and this claim has certainly been borne out in those factories which have installed them. In the most modern driers, flue gas temperatures are as low as is practically necessary and the fitting of an economizer should therefore be unnecessary.

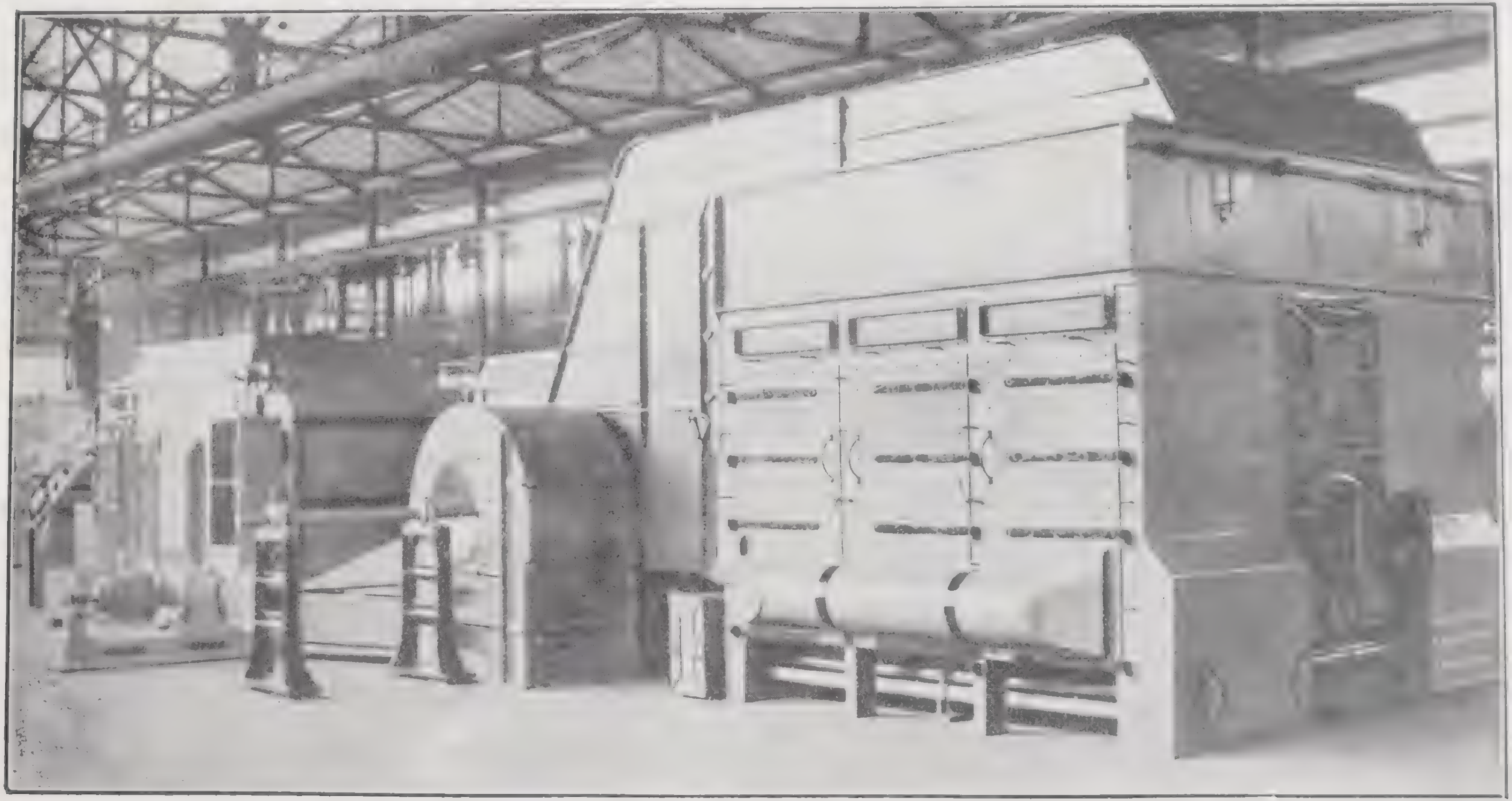
REMOVAL OF EXHAUST AIR

A very common cause of stewed teas and inefficiency in driers has been due to the fact that moisture-laden exhaust air from the top of the machine is not able to get away quickly from the drying room, and so passes back into the stove. Efficient roof ventilation is an essential in drying rooms, and if this is absent it is necessary to lead the exhaust air out of the room by means of ducts. Until the Government by means of the Factory Act insisted that the atmosphere of drying rooms should be made reasonably comfortable for the operatives, little or no attention was paid in many factories to the removal of hot, humid, exhaust air. The Factory Inspector may insist on the installation of ducts if he thinks conditions require them, and often his insistence in this matter not only improves conditions for the firing men, but results in direct improvement to the tea, economy in fuel and greater efficiency of the firing process.

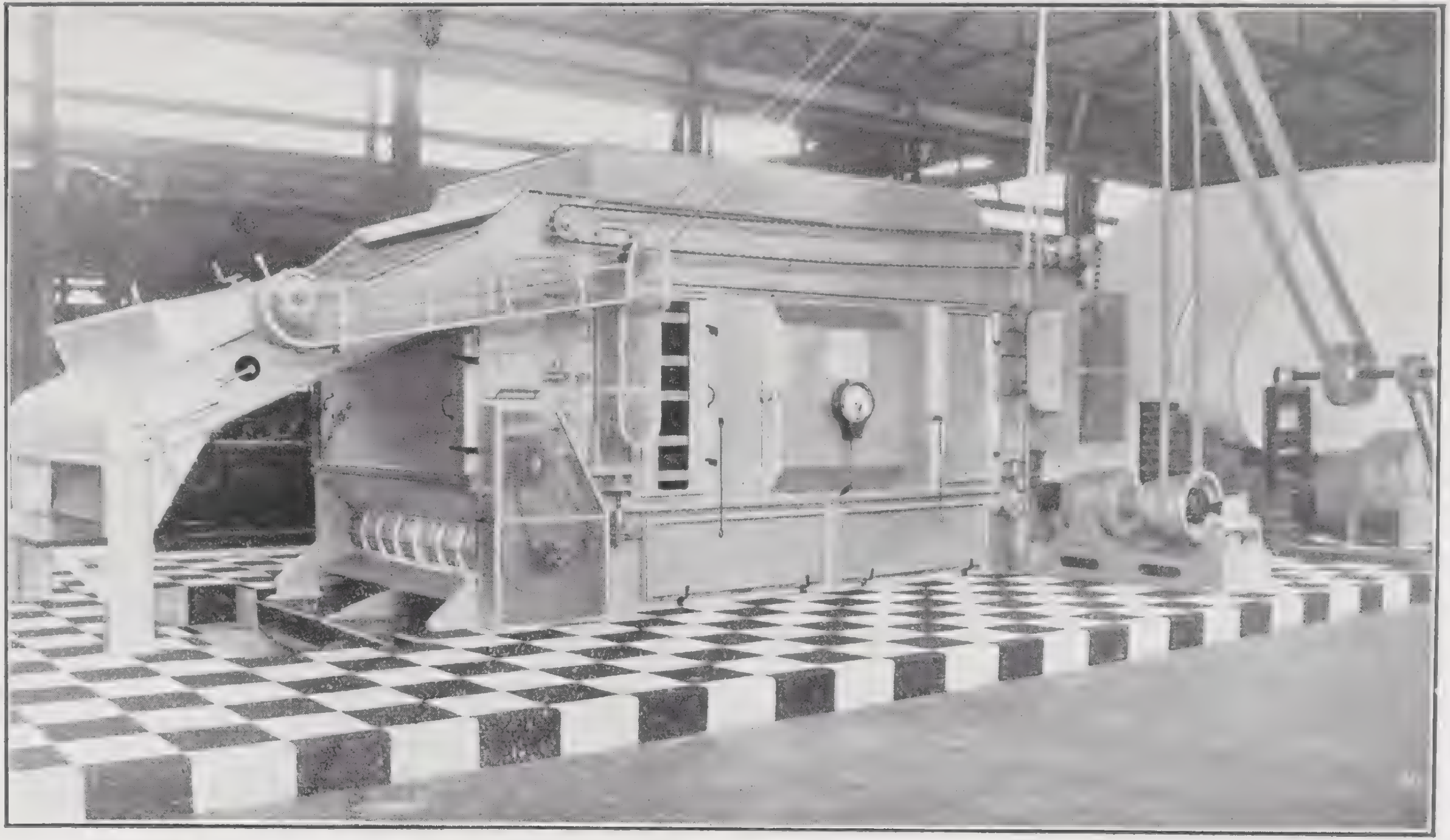
In designing and installing hot air ducts, the ideal to aim at is to have the ducts as short as practicable, with as few bends as possible, and as little as possible reduction in cross sectional area, compared with the area of the top surface of the drying chamber. If these conditions are observed there is little or no fear of ducts causing back pressure of air in the drying chamber.

DRIER THERMOMETERS

Up till recent times driers have been fitted with two brass-cased mercury thermometers, one on either side



Farbridge "Multi-Flue" Drier Stove.



Farbridge "Multi-Flue" Tea Drier.

of the machine in such a position that they give the temperature of the air just before or just after entering the bottom of the drying chamber. The stoker is supposed to watch these thermometers and to adjust stoking so as to keep as steady a temperature as possible, at whatever the figure he has been instructed to maintain. There are obvious objections to this system of control. Firstly unless very adequate supervision is possible, anything may happen! The stoker may raise a good fire, sufficient to last some considerable time, and then go round the corner for a smoke or a rest. The temperature of the machine may thus fluctuate between wide limits and the tea come out at anything between 8 and 16 annas fired. Secondly, in the case of first firing, the inlet temperature is not really the important temperature in the machine. As has already been explained the best results are obtained by keeping the exhaust temperature constant, and this means some variation in the inlet temperature to deal with variations in the wither of the leaf, rate of feed of leaf into the machine etc.

In more recent years automatic recording thermographs have become popular and these provide a complete record of the day's firing temperatures, if used properly. Many driers are fitted with one thermometer below the top or second tray, and one at the inlet, both working on the same recording dial. It is essential to test these instruments from time to time against a true reading mercury thermometer. In second firing machines, a single thermometer in the air inlet only is required, this being kept at 180°F.

DRYING EQUIPMENT REQUIRED

Some years ago the following firing machinery was considered adequate for a crop of up to 4,000 maunds—one 4 feet Empire or E. C. P. for first firing and a single Tilting Tray or 6 feet Venetian machine for second firing; and for a crop of 4,500 to 6,000 maunds, a 6 feet Empire or E. C. P., and a double Tilter or 10 feet Venetian. This equipment would nowadays be consi-

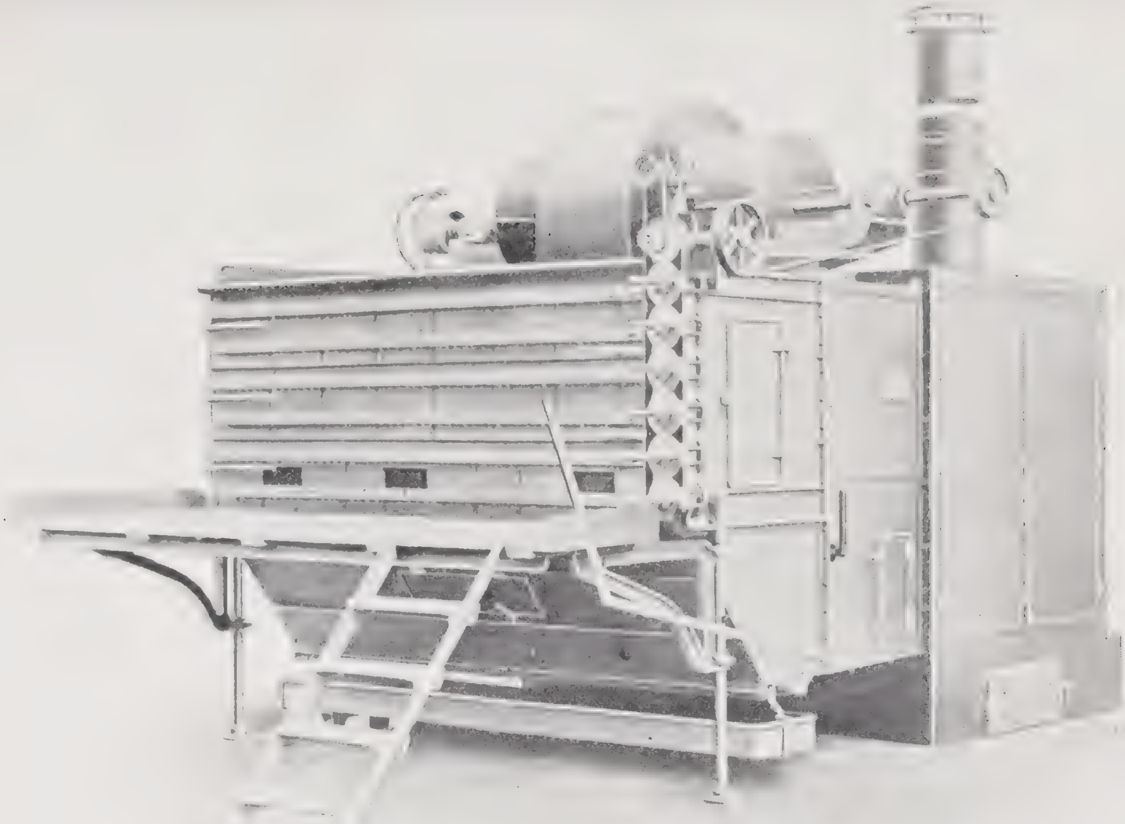
dered rather inadequate as it involves very long working days at rush periods of the season. For a 9,000 maunds crop, working the rolling system described in the last chapter, which provides about 1,600 lbs. of rolled leaf per hour, two large first firing machines and two large second firing machines are necessary to keep pace with the supply of leaf.

CONTINUOUS FEED TO FIRING MACHINES

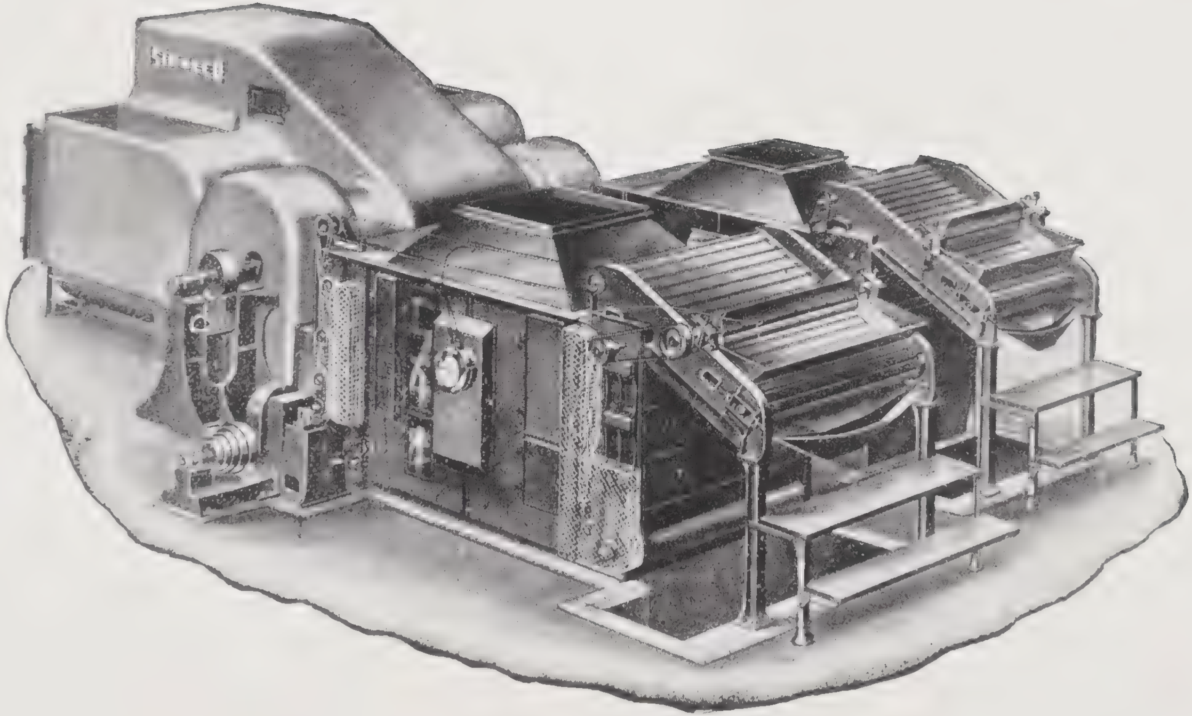
It is very desirable to have a constant supply of fermented leaf, enough to keep the first firing machines full. Gaps in the drier between successive "*ghanis*" of leaf are not desirable, and they reduce fuel economy. In order to keep the machines full it is necessary to begin lifting a "*ghani*" about a quarter of an hour before the average fermenting time, and to finish loading it into the machine about a quarter of an hour late. Actually a quarter of an hour's difference one way or another is found to make very little difference—so little that tasters seldom detect any difference in the teas made.

DRIER FUEL AND FUEL CONSUMPTION

Many years ago firing was practically universally done with wood fuel, and many factories still use wood when available. The removal of old shade trees and uprooting of old tea provides a considerable store of wood for the driers, especially on gardens where the labour force have ample supplies of firewood from other sources. As a general rule however coal and to some extent oil are used for heating driers. It is difficult to give average figures for fuel consumption in driers; so much depends on the degree of wither aimed at; whether the drying equipment is such as to give economical running with the rolling machinery available; temperature of firing, type of machines and other factors. With all factors favourable a coal consumption of the order of $\frac{1}{2}$ to $\frac{3}{4}$ maund of coal per maund of tea can be reckoned as a satisfactory figure. To get down to the lower figure



10 ft. Improved Imperial Venetian Drier (Marshall).



"SIROCCO" 6 ft. -4 ft. Super Combination E. C. P. Drier.

however, not only must all the above factors be satisfactorily adjusted, but the stoves of the machines must be properly insulated, and fuel economizers, such as those described earlier in this chapter, must be installed. Gardens making tea on the "no wither" system will naturally have higher coal consumption for their driers than gardens working on the ordinary system, other factors being the same.

The stoves of modern machines are much better designed for coal and oil fuel than the older types, in which the stoves appear to have been designed primarily for burning wood fuel.

To show the wide variation in quantity and cost of fuel consumption in driers the following figures are given :—

Per maund made tea :

Wood	...	1·2 ta 4·0 maunds	costing	3·8 to 27·9 annas.
Coal	...	0·5 to 1·2 ,,	,,	5·0 to 12·0 ,,
Oil Fuel	...	0·23 to 0·40 ,, (18 to 31 gallons.)	,,	7·8 to 13·7 ,,

The costs in each case are pre-War costs. At the present time these may be multiplied by at least three.

CHAPTER XVIII

SORTING AND PACKING

THE sorting room should be well lighted, well ventilated, and separated from drying and packing rooms, workshops, etc., from which undesirable foreign matter such as nails, filings of metal, bits of wood, etc., might find their way into the tea.

During the process of sifting tea, a good deal of light fluffy matter becomes detached, and unless steps are taken to prevent it, clouds the atmosphere of the sorting room, gradually settling on every part of the room.

In order to maintain an atmosphere free from fluff and dust, some mechanical device for extracting fluff and dust from the air close to cutters, sorters, etc., is most desirable. Exhaust fans in suitable places in the walls help to remove the dust laden atmosphere from the sorting room, but a system of suction ducts with openings over each machine is by far the most efficient scheme for keeping the sorting room atmosphere pure.

The fluff is the thick hairy down which may be observed on the buds and on the underside of fresh young leaves. It is this fluff on the young leaves and buds which during manufacture assumes the orange colour which gives the name to orange pekoe or flowery orange pekoe. The slightest friction detaches it from the leaf; hence the necessity for great care in manipulating tea after it has become crisp in the process of drying. This fluff is sometimes described as "bloom" because it plays so important a part in tea with a good appearance; apart from this it is not of much value, as upon infusion it does not give much depth of liquor, nor does it improve the flavour or aroma in the cup.

CAFFEINE

Although tea fluff is so light in weight as to rise readily in a cloud during sifting operations, yet if it is

carefully swept up from the floor daily, the weight reaches a very respectable total by the end of the season. Tea fluff as well as waste tea of all kinds is saleable in Calcutta and is used by chemists for the manufacture of caffeine.

SORTING MACHINES

There are several kinds of sorting machines in use, the chief distinction being those which revolve and those which oscillate. In all cases the tea is made to pass over wire mesh which is agitated in such a way as to encourage as much as possible of the tea to pass through the mesh.

Either class of machine may be very effective when carefully worked, but the rotary types of sifters are generally considered essential for making true leaf grades, many types of flat sifters are on the market and do very good work, especially in sifting out broken grades and they get through an enormous amount of tea per day. Among these the Moore's, Magic, Chalmers, Macintosh, Dixon, and Arnott's sorters are much in favour in North-East India. The latter four are newer types and are considered by many planters to cause less greying than the older types, possibly because they impart a hopping motion to the leaf over the mesh instead of the sliding action given by the older types of sorter.

OBJECT OF SORTING

The object of sorting is to separate the different classes required, with completeness, from the bulk or mass of tea with the minimum of friction and consequent dust.

At one time the process of sorting did not mean so much the classifying of teas as the sorting out of any unsuitable hard leaf which inadvertently got into the tea, and which instead of taking on the usual twist, had become flat red leaf ; also sorting out long stalks and all foreign matter, such as chips broken from leaf baskets or mats during the various stages from the plucking of

green shoots to the final drying process. Sorting was chiefly done by hand, sometimes with a pair of tweezers made of bamboo. The process of grading teas was termed sifting, but nowadays sifting and sorting are synonyms for the whole process.

STALK

There is a strong trade objection to the presence of stalk in the teas. No doubt many consumers look upon stalk as an impurity, although there is behind this attitude more prejudice than knowledge. When stalks are picked out from the tea and infused by themselves the resulting liquor is found to be strong and coloury, with a nutty flavour which is not unpleasant. The appearance of stalk in the tea is against it, especially when in process of rolling, the bark has got rubbed off and the stalk looks like a dry stick. It must be prevented and eliminated as far as possible.

CAUSES OF STALK

There are several causes which tend to the production of stalk. Coarse plucking produces tea consisting of large leaves and long stalks. Stalk also results when bushes are plucked very close to red wood. Healthy bushes, with large plucking surfaces, if plucked fine over a good initial growth, especially if a leaf is left later in the season when the new wood has begun to harden up, produce the minimum stalk.

Another cause of stalk is commonly supposed to be excessive shade over the tea bushes. The effect of shade under a dense tree is to encourage "a drawn out" growth in the tea, a few shoots here and there suddenly running up long, producing almost more stalk than anything else. It seems to be a natural effort of the bush to throw out a few arms as long as possible, with a view to getting out into the sunlight . For this reason, all shade trees should be trained to give a lofty shade, by lopping lower branches when young; and shrubs such as Medeloa, etc.,

should be kept rigorously under control by frequent lopping.

Among the causes of stalk which are beyond the control of the planter are the various peculiarities of weather and season. At some seasons there is a tendency to stalky growth more or less on all estates. A spell of cloudy weather, lasting for several weeks in midseason, is always certain to result in an abnormal growth of stalk.

In pre-war days plucking was, with a few exceptions, of a generally fine standard on most N. E. Indian tea estates, and a stalk removal was not a great problem. Since 1942 the standard of plucking has deteriorated, resulting in a great increase in stalk; and recently complaints have been made by the brokers, of excessive stalk in the teas from N. E. India. It is a curious fact that while stalk itself makes quite a fair liquor, and tip, a poor one, the former is regarded as indicating a poor tea while the latter indicates a good one, in general. There is however a rational explanation of this apparent prejudice. Stalky teas are generally the result of coarse plucking, and possibly, of careless manufacture, resulting in common liquoring teas, while the presence of tip indicates the opposite—fine plucking combined with careful manufacture.

Women are generally found to be best for the work of the sorting room. Usually the tea is picked over twice—once before sorting and once after; there are however machines such as the Myddelton and Bateman's stalk extractors which claim to be efficient, and certainly help greatly in removing a great deal of the larger stalk.

More recently, a machine known as the Andrew's breaker has been introduced for breaking up the dry tea after firing. In this machine the tea is passed between two large fluted rollers whereby the black tea is broken up, but the stalky part is left intact, and can be removed easily by suitable sifting. The machine does not cause greyness—commonly associated with the use of some of the old types of tea breakers and cutters. A common cause of greyness in the coarser

grades is the picking out of stalk by hand from tea spread on rough cement floors.

UNIFORM TEAS

It is well to have as few classes or grades as possible and to keep the crop produced by any one estate as uniform in character month by month as the circumstances permit. The making of a large number of grades involves turning out very small percentages of some grades; these have to be stored in the factory often for a considerable time, in order to collect enough for a break. Moisture is picked up inevitably, and the teas require considerable final firing which does not improve their quality and briskness. However if a garden is doing well by making a certain assortment of grades it is unwise to start altering things. Large buyers of tea like to know what sort of article to expect from any particular mark, and if they can depend upon it, are more likely to give such a mark their attention.

GRADES OF TEA

Many gardens in North-East India make eight grades of tea, viz., Broken Orange Pekoe (B.O.P.), Orange Pekoe (O.P.), Orange Fannings (O.F.), Broken Pekoe (B.P.), Pekoe (P.), Broken Pekoe Souchong (B.P.S.), Pekoe Fannings (P.F.), and Dust. The first three (orange) grades are composed of the finer portions of the shoot, i.e., the bud, first leaf and softer part of the stalk. The B.O.P. grade is smaller in size than the O.P. which should consist of long tips and thin wiry and twisted pieces of leaf and young stalk. The two fannings grades consist of very small pieces of leaf broken off during rolling and sifting. B.P., P. and B.P.S. are coarser grades made mainly from the larger first leaves, second and third leaves and the intervening stalks. Dust is, as the name implies, the smallest grade, consisting merely grains of tea. Some gardens, especially those in quality districts, often make a Flowery Orange Pekoe and a No. 1 B.O.P., these being very tippy grades.

Percentages of grades vary on the same garden according to the period of the season, and also show great variation between gardens even if working on similar systems, but the following may be given as typical of many :—

	Per cent.		Per cent.
B. O. P. ...	30	P. ...	7
O. P. ...	10	B. P. S. ...	8
O. F. ...	7	P. F. ...	10
B. P. ...	23	Dust ...	5

Some gardens combine Pekoe, B.P.S. and B.P., others make only one fannings grade. Many gardens nowadays make no "leaf" grades (O.P. and P.) and thereby simplify sorting tremendously. In the "no wither" system of manufacture, flaky grades, unlike any of the standard grades except possibly fannings, are made; often only three grades are produced, viz., about 75 per cent of a so-called B.O.P. together with some fannings and dust.

DUST

The liquors of dusts are often very good, but until recent years this grade was not favoured because of its small size and its awkwardness in the tea pot. It is impossible to blend a dust satisfactorily with other grades. In latter years there has been a very good sale for dusts on the Calcutta market for internal consumption, a better sale in fact than for many B.P. and B.P.S. grades. Consequently many gardens have made a point of making as much as possible of their tea for internal consumption in India into dust.

An important error to guard against is the inclusion of dust in other grades, especially for the London market, which demands clean true grades. It is however a fact that the vigorous shaking of chests during packing, combined with the crushing of the tea when the lid is nailed down, results in the abrasion of larger particles of tea to dust. This is said to occur more especially with

teas manufactured with the C.T.C. machine, or under the "no wither" system.

FANNING MACHINE

For removing fluff, dust and fannings from larger grades a machine known as the Macdonald Deflector is invaluable and is in use in many factories for cleaning up grades.

CUTTERS

It is general practice to put the tea through cutting machines at some stage or stages during sorting, in order to reduce large pieces to a size suitable to the various grades. The old types of machine, which broke rather than cut the tea, and thereby produced much dust and greying, have been superseded by machines such as the Savage and Clark Cutters which make a clean cut, and do the work much more efficiently and quickly. These machines should not be run too fast, certainly not more than the speeds advised by the makers; a fast running cutter tends to cause greyness, and there is little increase in the output of the machine.

LOOSE TEA

After sorting has been completed no tea should be kept lying loosely in boxes or other open receptacles. Tea attracts and absorbs moisture from a damp atmosphere very rapidly. Any considerable quantity of moisture soon leads to softness and mouldiness, which means deterioration often to an extent at which the tea may become unsaleable.

SOFTNESS AND MILDEW

When once a tea gets slightly soft, the process of decomposition has begun, and some of its best properties are lost. Refiring will check this, but it can never restore to the tea any of its lost constituents, or the perfection of flavour and aroma which it possessed before.

If teas are packed as soon as possible after manufacture, there is no danger of harm by this means, provided that the firing has been correct and they do not contain more than 5 per cent moisture.

BINS

It is always the practice nowadays to store tea in bins until there is sufficient of each class to form a break. Bins should be well constructed and as air-tight as possible to reduce absorption of moisture by the tea to a minimum. It is preferable to have bins constructed with a narrow cross section, rather than short and squat; so that the surface area of exposed tea in the bin is as small as possible. Bins should be raised off the ground and situated in a warm dry part of the sorting room.

FINAL FIRING

Before being packed, if the tea contains more than 5 per cent moisture, it is necessary that it should receive a final firing, in order that the moisture shall be reduced to 5 percent. For this purpose it is usual to pass the tea through a second firing machine.

The temperature may be 150 to 180°F. depending on how moist the tea is. The air speed in the drier should be reduced as much as possible and the tea fed in evenly. Grades of which only small percentages are made generally need final firing, but often it is possible to pack other grades without this process, which does not improve the tea, but reduces its briskness. Final firing must be regarded as a necessary evil, to be avoided whenever possible.

COOLING

After final firing, it is desirable to cool the tea before packing it in the chest. The turning over during bulking secures this, and the tea can be sealed up warm but not too hot.

BULKING

The factory is the natural and proper place for bulking to be done. If reasonable care is exercised, it can be done both cheaper and better than in dock warehouses; and the chests being properly sealed up, should be allowed to remain so until the tea is to be blended or put into actual consumption. Whether the teas are to be rebulked in London or not they should always be thoroughly bulked at the factory. This may be done partly before final firing, by arranging that a basketful of the first and of the last manufactured tea should be fed into the machine alternately. The real bulking, however, must be done after firing, because in case of any irregularity in feeding or in temperature during the process some portion of the tea may come out more or less fired than the rest.

PROCESS OF BULKING

A thick canvas sheet is spread upon the floor of the packing room. Round this are ranged in a circle the baskets of tea as they come from the drying machine in regular rotation. After the whole of the tea comprising the break has been so arranged, the first basket of tea is tilted upon the centre of the sheet, then the last one, and so on alternately, each lot being tilted over the centre of the heap. After the whole has been heaped together, a new heap is begun by shovelling from the old heap with wooden spades, again taking care that the tea is all tilted over the centre, when the bulking may be considered complete.

PACKING MACHINES

There are several styles of packing machines in use. All are worked on pretty much the same principle. The chest is held in a clamp on the machine, and is subjected to a very rapid vibratory motion as the tea is poured into it.

CLEANLINESS OF SORTING ROOM

Many sorting rooms, especially some few years ago, were most unpleasant places to spend more than a few minutes in. The atmosphere was thick with fluff and dust which settled over floors, machinery, heaps of tea and even the windows, making things not only unpleasant and unhealthy but increasing the work required to produce clean grades of tea. Most sorting rooms nowadays are provided with exhaust fans in the walls for removing dust and fluff, but this system is by no means the best.

A system of exhaust air ducts from each cutter and sorting machine is essential to maintaining a dust-free atmosphere. The system should be carefully worked out, using either overhead or underground ducts, which need to be graded in cross section according to the distance from the exhaust end. All sharp corners and rough inside surfaces should be avoided. Light metal sheets or venesta panels are suitable materials for constructing these ducts.

TEA CHESTS

Many makes of chests are used for packing tea, mostly of three plywood, lined with aluminium foil and paper, the paper being next to the tea itself. Imperial, Orient, Venesta, Luralda, Ajax and Hercules are all well-known makes of tea chest and except for tea sold for internal or local consumption, little tea is packed nowadays in the old type of *Simul* chest. The ordinary size of chest holds 100 to 130 lbs. of tea according to the grade of tea packed. There are also half chests for special grades, e.g., very tippy orange grades. Dust is packed in 80 lb. chests. It is usual to send off invoices of tea in multiples of 6 chests in the case of each grade. Chests are marked "Pure Indian Tea", and have the total gross weight, net weight of tea, invoice number, serial number, garden mark and name of wharf of which the invoice is consigned. If the teas are factory bulked this also is usually stated on the chest.

ELIMINATION OF FOREIGN MATTER IN SORTING AND PACKING

In order to prevent the inclusion of foreign matter in teas during sorting many precautions are taken nowadays. Magnets are fitted to sorting or packing machines to remove pieces of iron or steel, such as nails, nail heads, screws, pieces of wire from sifters, etc., and iron filings. Trays with suitable sized mesh are often fitted over the chest in the packing machine, the mesh being of such a size that it just allows the tea to pass through easily, but retains bits of bamboo and bristle, larger insects and other foreign matter.

The sorting and packing rooms should be very carefully swept prior to each manufacturing season, and at intervals during the season whenever practicable. Particular case must be taken to avoid getting glass into the tea. For this reason glass fermenting floors are not recommended.

Whenever a pane in a factory window breaks, the broken glass should be very carefully swept up and removed. Before packing all boxes should be carefully inspected. The "mati-wasp" has a habit of building its nest in a corner of a tea chest left empty and open for even quite a short period.

As far as possible packing should be done by daylight to avoid trouble from night-flying insects which may easily get into the tea during bulking and packing. If it is necessary to pack at night, electric globes should be fitted with wire mesh insect traps. A system of floodlights, situated in corners of the room remote from the packers, is a good scheme.

CHAPTER XIX

CRITERIONS OF TEA VALUE, AND FACTORS AFFECTING IT

It may be accepted as a general rule that slowness of growth tends to quality, though a large crop per acre is not necessarily incompatible with fine tea, any more than that a small crop necessarily means fine tea, as some people too readily assume. Many estates both on the hills and the plains yield a very small quantity of tea per acre, and yet remain near the bottom of the list in regard to prices. On the other hand many Upper Assam gardens give large crops of some of the finest teas in the world.

RAPIDITY OF GROWTH—HEAVY PRUNING—SICKLY BUSHES

Anything which promotes slowness of growth, without in any way diminishing the normal health of the bush, tends to improve the quality of teas produced. Whatever promotes very rapid growth has generally the contrary effect. This is always observable during a sudden rush of leaf in consequence of especially favourable growing weather, and it is probably the chief explanation why many of the districts which produce large crops very seldom get fine prices; and even on those rare occasions the good quality is due to special causes which to some extent retard the growth for a time, as well as to the alertness of the manager who takes full advantage of the special circumstances,. In the same way it is invariably the case that after heavy pruning, if the bushes are allowed to get a proper start, growth will be exceedingly rapid, but it is impossible to make fine tea from the leaf produced. On the other hand, if, after heavy pruning, a system of close plucking is adopted, some very fine teas may be

made, but this is due not to any cleverness or care in manufacture; it is simply because the bushes have been checked by the closeness of the plucking and the growth stunted. In this case the roots are putting forth a desperate effort, and the bushes are endeavouring in vain to cover themselves with foliage to replace that which was cut away. When this special effort is expended, the bush gradually lapses into a sickly condition. The observation of these results has led some planters to adopt the mistaken idea that in order to obtain fine teas the bushes must be brought into a somewhat sickly state. No greater mistake could be made, and it may be remarked here again that it is much easier to destroy health than to regain it.

QUALITY WITHIN LEAF—DESTRUCTION OF QUALITY

In order to obtain fine tea, the quality must be in the leaf itself when brought to the factory; otherwise, no skill or care in manufacture can possibly produce high class teas out of coarse leaf or even from finely plucked leaf or non-quality jat, grown under forcing climatic conditions. It must also be admitted that the finest leaf may easily be turned into bad tea by a wrong system or by absence of system in the manufacture.

THIN LEAF—GENERAL DEBILITY

Poor quality also results from leaf which, when taken between the forefinger and thumb, is found to be as thin as a newspaper. In this case the leaf cells are not well developed, and are practically empty of juice; the cause perhaps being a want of vigour in the bush, resulting from attacks of red spider or other blight, or perhaps from want of adequate manuring, cultivation, etc. Anything which causes general debility will eventually tend to the production of weak tea.

EARLY SEASON—OLD LEAF

In the earlier stages of the season after the first flush, it is necessary to allow a shoot to develop pretty fully before plucking. At this stage it will be found that the best tea can be made when the shoot has developed four or five leaves so that in plucking the bud and two leaves, the plucker has to leave at least two or three excess leaves behind. There is a stage beyond which a flush should on no account be allowed to run; if this happens plucking inevitably results in coarser leaf, giving poorer stalky teas, and crop is lost by breaking back very long shoots.

END OF SEASON

Towards the end of the season everything, even the smallest shoots on the bush, may be plucked; no harm can be done at this stage even by plucking *below* the plucking level, in order to get the largest possible crop of good autumnal tea.

APPEARANCE OF LEAF

Good quality leaf, when plucked, is usually of a light green or yellowish colour and thick texture, with a more or less stunted appearance. The fine large succulent leaves with long stalk and silky touch, such as came the first year from heavily pruned tea, are very pretty, but are not of good quality.

INDICATIONS IN FACTORY—COLOUR AND AROMA

During manufacture there are certain indications by which the expert tea-maker knows whether he has the right quality of material to work with. The leaf spread for withering will have a bright yellowish green appearance, and when properly withered fills the withering loft with a faint scent like the aroma of ripe apples. The scent emitted is quite strong when a handful of the leaf is taken and pressed together.

APPEARANCE OF JUICE—COLOUR OF FERMENTED LEAF

During rolling the juice is of course expressed from the cells of the leaf, and the whole becomes a wet mass. This juice should be thick and sticky; if it is thin and watery, the tea will not be of such good quality. During fermentation, the colour will come on readily on good leaf and will be bright from the first, whereas with leaf of inferior character the colour will tend to remain dark and greenish rather than the bright coppery colour desired.

INDICATIONS IN TESTING

In testing tea there are certain indications of quality, apart from the actual tasting of liquor, which to a very large extent guide the tea-maker of the tea-buyer.

The liquor of a good tea has quite a bright sparkling appearance immediately it is poured out.

CREAMING

If of the Assam variety, it will rapidly become milky as it cools down, until it gets quite thick and looks as if a quantity of milk had been stirred into it. This is usually the case with fine tea of this class, although not invariably so. With the China variety there is seldom any creaming, although the tea may be superior to the other in flavour, hence creaming cannot be taken as an invariable test of a good tea; but when present, it may be assumed that the tea is at least strong and good in quality. It is no indication of flavour.

COLOUR OF OUT-TURN

Bright infused leaf is almost invariably a characteristic of good tea. Something like gold, or like coppery colour is what is most desirable. Colour is not an absolute guide, however, because sometimes leaf which has been spoilt in the field by fermenting in the baskets,

may afterwords show up splendid colour on infusion, although the liquor produced is poor and weak. On the other hand, it has occasionally been found that tea with a remarkably fine flavour gives a dull dark infused leaf; this is a rare occurrence, however, and does not disprove the general rule. Rather it indicates that the best has not been made of the leaf in manufacture, bacterial infection possibly being present. Had this been eliminated the chances are that the teas would have been even better.

TEA TASTING

The ultimate test of tea is of course in the tasting; but very few people possess a palate of sufficient delicacy and steadiness to be relied upon. Probably not one man in five hundred is capable of becoming a really good and reliable taster. Many men can at certain times discriminate between teas with remarkable precision, but at other times are as far out as any one. A tea planter cannot be expected to be an expert taster, although he may come very near that description, and in any case it is part of his duty to taste and test his teas in every way possible, and to get all available assistance from professional tea tasters, in order to ensure that the daily manufacture is up to the proper standard, and that he is getting the best results possible in the circumstances.

TERMS USED BY TASTERS

The following is a list of terms in common use by tea tasters, together with explanations of the meaning of the terms. The list has been compiled from a glossary of tea tasters' terms which was approved at the end of 1937 by the London tea brokers.

Characters of the dry leaf.

(*a*) *Colour.*—May vary from *brownish black to jet black* and may have more or less *greyish* appearance

especially the coarser grades. Greyness is an undesirable character. Light leaf jats give brownish teas while dark leaf jats, e.g., Burma jats, give black teas. Brownness is therefore often associated with quality teas of the second flush and autumn especially.

(*b*) *Make.*—A grade should be *even*—consisting of pieces of reasonably even size—not a mixture of fannings and pekoe for instance.

Certain grades, O. P. for example, should be composed of *well twisted* pieces, indicating good withering and rolling. Grades containing much flat untwisted pieces are described as *flaky*, generally an undesirable feature, though "no wither" manufacture gives teas mainly of a flaky nature.

A grade showing signs of having been chopped in in the cutter or breaker after firing, rather than having been broken up in the roller, is described as *choppy*. Often, close examination shows that the pieces of tea of the pekoe type have whitish ends; *stalky* teas are undesirable, indicating as they often do, coarse plucked leaf. Stalkiness in autumnal teas is often overlooked if the teas are flavoury. Teas containing *fibre* are also generally undesirable; the fibre is produced from the outer skin of the stalky part of the shoot.

Tip.—Consists of buds, more or less covered with hairs, which may have absorbed juice during rolling to a varying degree which affects the colour of the tip.

Tip may be *golden, pale, silvery* or *dull.*

Certain jats produce more tippy teas than others, and climatic conditions also affect tip. Assam second flush teas are generally very tippy.

Golden tip. Resulting from a heavy deposit of juice on the tip hairs during rolling.

Silver tip. Resulting from a high wither and insufficient pressure in the first roll to express juice.

Pale tip. Only a thin coating of juice on the tip hairs may result from an under-wither, the juice subsequently expressed in rolling being thin and watery; also some jats have a poor development of hair on the buds, and produce pale tips.

Dull tip. Tip is a dull gold or rusty colour, and may be due to bad rolling, e.g., overloading rollers causing a shearing of much of the hair from the buds, this hair being plastered on the black leaf, and often giving it a greyish appearance after firing. Abrasion of tip during sorting may also cause dull tip.

Characters of infused leaf.

(*a*) *Colour* :—

Bright. Bright in colour denotes good tea.

Coppery. Bright copper colour denotes good tea.

Dull. Darkish in colour as opposed to bright, denotes a poor tea. Dull infused leaf is generally the result of insufficient attention to cleanliness in the factory.

Green. Greenish in colour, denoting as a rule thin liquors.

Even. No irregularity in colour.

Mixed (or *uneven*). The infused leaf contains a mixture of greenish or dark pieces along with the normal bright red colour. May be due to coarse plucking, *banjhi* leaf, or bad rolling conditions (e.g., overloading), removal of too much fine mal in green leaf sifting, or use of too large a mesh on the sifter.

(*b*) *Smell*, or "*nose*", should be fresh. Flavoury teas have a pleasant odour on the infused leaf. Flavoury teas vary in their smell, in some it resembles roses, others almonds, others more like the smell of a fruit preserve, e.g., black currant jam. Some teas have a malty smell, also noticeable on the dry tea and in the liquors.

The smell of high firing can also often be detected in the infused leaf.

Characters of liquors.

(*a*) *Colour.*—Coloury teas are, as the name suggests, deep in colour, though they may be weak to the palate.

A *light* liquor is one lacking depth of colour, but it may be flavoury or pungent.

A *bright clear* colour is a sign of a good tea and is generally accompanied by briskness.

Liquors which are neither clear nor bright are described as *dull* and are generally inclined to be soft or flat.

(*b*) *Taste.—Strength* denotes substance, and a certain amount of astringency in the tea. A combination of strength and colour is denoted by the term *thickness* and its opposite counterpart is *thinness.*

A *brisk* tea is one which has a "live" character, similar to the taste of fresh spring water as opposed to boiled rain water, or a fresh wine as compared with a flat one.

Fullness is a term used to describe a strong coloury tea with *body* or *substance.*

A *plain* tea is one lacking in any character.

A *pungent* tea is one having marked astringency; some tasters regard pungency as extreme briskness.

Quality denotes the presence of desirable character or characters and is not definable in precise terms. A quality tea bears a similar relation to a non-quality tea, as a liqueur brandy to a good ordinary brandy, or English to Canterbury lamb. *Jat* is probably the chief factor in deciding quality of tea.

Some tasters regard quality as the absence of any undesirable character.

Flavour is the most valuable character a tea can possess, and is influenced greatly by climatic conditions, jat, and altitude at which the tea is grown.

Dryness is a suspicion of high fired character; it may be likened to dryness in wines.

Maltiness. A desirable character (present in the leaf itself) which gives a taste or smell reminiscent of malt. To some it suggests high firing, though it is not actually produced by firing.

High fired teas have a distinct but possibly only slight flavour of scorching.

Baky teas are reminiscent of redried stale bread and bakiness is generally to be associated with bacterial infection.

Stewed teas are similar to baky teas, but have a suggestion of stewed vegetable. Again bacterial infection is indicated, or incorrect firing, e.g., exhaust temperature too low.

Sourness of teas is of two kinds, the sourness of acidity, e.g., unripe fruit, and the sourness of milk. Both may be due to bacterial infection during withering, rolling and fermentation.

Weathery teas are teas with an undesirable character, often resulting in mid-season rains teas. Bacterial infection on wet hessian cloth used for withering may be one cause of weathery teas.

Cream in liquors is a feature of a good tea. It is the cloudy precipitate formed when the liquor cools. Good Assam teas, especially in the second flush, cream well.

CHAPTER XX

GREEN TEA

THE chief feature in the manufacture of green tea, as distinguished from black, is that the green does not undergo any process of fermentation, while the slow operation of natural withering or wilting is replaced by the more rapid one of steaming.

GREENNESS RETAINED

Immediately the leaf is brought in from the field, its manipulation may be undertaken. When leaf has to be kept overnight, it must be kept in a perfectly cool and moist condition, so that its freshness and green colour may be retained. In hot weather it may be necessary to add a sprinkling of water.

PANNING

The first process, according to the old Chinese method, is that of panning or steaming, the object being to render the fibre of the leaf soft enough to stand rolling or bruising without being torn to fragments.

For hand manufacture, the pan is a large cast-iron vessel, shaped like a wash-basin, which is built into a brick stove in such a manner as to resemble a basin let into a wash-hand stand. The front of the stove is about three feet high, and the back a foot higher, so that the pan is on a slant, and the operator can stand in front and work at it conveniently. The stove is fired at the side or the back, so that heat is applied to the bottom of the pan, while the smoke or charcoal fumes are carried away by means of a chimney.

STEAMING AND ROLLING

When the pan is roasting hot (about 250°F.) a small quantity of leaf is thrown into it, and is kept tossed about by hand, so that no portion is allowed to rest upon the hot iron long enough to get singed. Under the influence of this heat, the moisture in the leaf soon begins to escape in the form of steam which rapidly causes the leaf itself to wilt or wither.

As soon as the leaf has become soft enough to stand a light rolling, it is whisked out of the pan and is rolled gently by hand on a bamboo mat while steaming hot.

After a few minutes, it is again thrown into the pan to undergo a further steaming, being steamed and rolled alternately until the leaf begins to get slightly crisp.

While manipulating the leaf in the pan the operator requires to have a pad of cloth in one hand, with which to rub off any leaf which might stick to the bottom of the pan.

When very wet leaf is treated, care must be taken that not too much is introduced to the pan at one time, because the excessive amount of steam emitted is apt to cause the leaf to ferment and become discoloured.

DRYING

As soon as the leaf begins to get dry and slightly crisp, it is taken to the *chulas*, where it is slowly dried upon trays over charcoal fires until perfectly crisp.

No time must be allowed to elapse between the panning and drying as no opportunity must be given for the leaf to ferment. If the leaf is allowed to undergo any degree of fermentation, the distinctive character of the tea is injured and the result is something like a black tea.

COLOURING—QUANTITY

When tea is manufactured in the above manner, it turns out an irregular dirty green colour, not

particularly attractive in appearance. The fine leaf may have preserved a clear green colour, but the coarser leaf is a blackish grey and spoils the appearance of the whole. The Chinese long ago recognized the impossibility of making coarse leaves retain their green colour during manufacture, and they resorted to the dodge of adding a colouring matter, by which the whole tea is faced and greatly improved in appearance. Various substances have been used for this purpose, including turmeric, Prussian blue, indigo, sulphate of lime or gypsum, etc. The colouring pigment is added at the final stage of panning after rolling has been completed. In the Kangra Valley, the substance commonly used for facing teas was powdered soapstone, of which about a tea-spoonful was required for four pounds of tea.

DESCRIPTION

Tea, which has not been faced, is variously described as "Natural Green Tea", "Unfinished Green", etc., while the faced tea is often described as "True Green" or "Finished Green". The general feeling of planters in India seems to be distinctly opposed to artificial colouring of any kind, as being undesirable; the finished greens are made only for certain markets where natural greens are not accepted.

REVIVAL OF GREEN TEAS

In the early days of the Indian Tea Industry, both green and black teas were generally manufactured; but after a few years the manufacture of green teas gradually ceased, with the exception of a small quantity which has regularly been made in the Kangra Valley for sale in Persia and Afghanistan, and by a few gardens in North-East India for the American market. During 1902 a few more estates commenced the manufacture of greens, chiefly in order to supply the American market, which however still draws the bulk of its supplies of green tea from China and Japan, though the one-time

preference for green as distinguished from black tea has in more recent years lessened greatly.

GREEN TEA IN ENGLAND—AMERICAN MARKET

When England drew her supplies chiefly from China, a considerable proportion of the tea consumed was green, but as Indian and Ceylon teas gradually displaced those from China, the trade in greens has been nearly obliterated, although the trade in black tea from China is still considerable. It was natural that the same thing should happen in America, but at the time the planters of India adopted the wise policy of catering for the actual demands of the market, until the American people acquired a taste for the more mature and full-bodied beverage.

MACHINERY

In view of the rapid revival of green tea manufacture some years ago, several inventors patented machines for the special work. The panning by hand was replaced by steaming and draining machines, and a machine was patented which the inventor claimed would combine also rolling and partial firing in one operation. Special machinery can now be obtained from Engineering Firms in Colombo and Calcutta.

There are gardens in North-East India on which the manufacture of green tea is carried out during the whole, or part, of the season. The entire exclusion of the withering and fermenting stages necessary to the manufacture of black tea, renders the whole process of manufacture of green tea a simple one in comparison with that of black tea, variations in weather conditions exercising little effect on the manufacture of the former type of tea.

While this is so, green tea making requires as much, if not more, care and supervision than does black tea manufacture, since the plea of unfavourable weather

conditions cannot be advanced as an excuse for poor quality of the unfermented product.

THEORY

The theory of the manufacture of green tea is as follows :—

In the modern process the tea leaf undergoes a process of steaming whereby all the chemical changes connected with withering and fermentation are checked. These changes ordinarily go on under the influence of complex substances called enzymes, and it is the destruction of these latter in the steaming process which prevents the wither and fermentation from taking place. The succeeding processes of centrifuging, rolling, drying, and sorting are, so far as can at present be ascertained, connected with no chemical change and merely bring the leaf into a suitable condition for the market. It will be realized that, with the omission of the withering and fermenting processes, the time taken in manufacture from the time the leaf comes into the factory to the time it leaves the drier after the final firing to 16 annas, is scarcely more than two hours, as against an average of 24 hours for the manufacture of black tea.

TYPE OF LEAF REQUIRED

Since the mechanical stalk extracting is a very difficult process to carry out satisfactorily on green tea, it is essential that good quality leaf with small shoots shall be plucked. Leaf attacked by red spider or mosquito shows up clearly in the infusion as red or discoloured leaf, and as such, detracts considerably from the value of the tea, which should give a completely green infusion.

The practice of pressing down the leaf in the plucking basket or in leaf gharries is a bad one and should always be discouraged since it causes the leaf to heat up, and results in reddening. This reddening is a sign of chemical changes having taken place and in consequence the liquors of the leaf made may have an

orange or reddish appearance. In addition the infused leaf is reddish. Such teas command much lower prices than those giving bright green infusions and pale greenish-yellow liquors.

Often the evening leaf is not manufactured at once but is spread about 6 inches deep in a cool place, e.g., on the floor of the fermenting room (which will be out of use at the time, if black tea is not being made). As early as possible next day, this leaf is steamed and manufactured. If, as often happens, the night has been hot, some withering takes place, and teas made from leaf kept overnight are poorer in quality than teas made from leaf manufactured immediately. Much can be done to arrest any withering while the leaf is on the floor of the fermenting house, by spraying it with clean water. For this purpose, ordinary garden sprayers or syringes with fine nozzles are very convenient. If the leaf comes in saturated with rain water as a result of a heavy shower before or during plucking, spraying need not of course be resorted to.

During the middle of the rains, when the quality of black teas is at its poorest, the quality of green tea should be at its best, the humidity of the atmosphere preventing to a great extent any withering likely to take place before the steaming operation. Moreover, the leaf on the bush gets more shade during the rains when not only are shade trees in full leaf, but the weather is naturally more cloudy. This excess of shade produces better quality of leaf for green tea, and the final product has a deeper green colour.

PROCESSES OF MANUFACTURE

The first operation, namely steaming, is carried out in a cylindrical drum of wood or metal, rotating on its longer axis at about 15 r.p.m. The charge is about 200 lbs. of green leaf, and the length of time each charge is steamed is from 2 to 3 minutes. Steam at a pressure of 20 to 30 lbs. per square inch is led into the drum at either end, the steam pipes forming the spindles

on which the drum rotates. As each charge is finished it is emptied out on to the floor and cooled with cold water. Two charges, i.e., 400 lbs. of green leaf, are then put into a centrifugal machine, or hydro-extractor, revolving at about 1,000 r.p.m., and a considerable quantity—about 15 gallons—of yellowish liquid is expressed. This liquid contains about ½ lb. per gallon of solid matter, of which 2½ oz. are tannin and ½ oz. is caffeine.

After centrifuging for about three minutes the leaf is removed and rolled with no pressure.

The length of time of this roll varies in different factories from ten minutes to half an hour. After rolling the leaf is put through a drier, and dried off to a degree which varies considerably in different factories. In some factories it is dried only to about six annas, and in others to a degree just short of crispness. The semi-dried leaf is rolled again and kutcha sifted. A suitable scheme for rolling is 20 minutes medium pressure with a kutcha sift, then 40 minutes medium heavy pressure followed by another kutcha sift to break up the balls of leaf.

The leaf is then dried either in one or two operations exactly as in the case of black tea.

The "rough mal" is a dark olive colour and stalk shows up almost white. This is picked out by hand from the cut mal, as the use of a mechanical stalk extractor causes flakiness, and gives, instead of twisted grades, a large percentage of a grade similar in appearance to the Souchong of black tea. Such a grade is undesirable and would get only a low price in comparison with well twisted Hyson.

After sorting, the teas are in some factories given a polish by placing the tea in a narrow cylindrical iron drum with 1 per cent of French Chalk, and rotating the drum for about two hours. This process is also called "glazing" or "facing". In some factories, especially those who make teas for the American market, "facing" is left out, the teas being sent away without any polish.

The following are typical green tea grades:—

Fine Young Hyson; Young Hyson; Hyson No. 1; Hyson; Twankay; Fannings or Soumee; and Dust.

In one or two gardens, the Hysons are combined into one grade called Young Hyson, which forms about 90 per cent of the invoice. The remaining 10 per cent is made up of 2 per cent Twankay, 3 per cent Fannings, and 5 per cent Dust.

COMPARISON WITH BLACK TEAS

The total tannin in green tea is always higher than that of black tea made from similar leaf. The reason is that during the fermentation of black tea a certain percentage of tannin is converted into red and brown substances, some of which are not extracted by hot water and remain on the leaf to give it the characteristic reddish brown colour. The longer the fermentation and the warmer and drier the fermenting room, the greater is the production of insoluble brown substances, and therefore the lower is the tannin content of the final product.

This loss of tannin is not undergone in green tea manufacture since there is no fermentation, and a high tannin content in the final product results, the only loss being due to expression of juice in the hydro-extractor.

With regard to caffeine there is no apparent reason why black and green teas should differ, but it is usually found that green teas contain more of this stimulating substance than do black teas.

In a cup of black tea there is little less tannin than in a similar infusion of green tea, but whereas in the former case some of the tannin is in the form of reddish brown, tasteless substances, we find in green tea liquors all the tannin in the form of astringent colourless tannin. The caffeine extracted in a cup of green tea is always considerably higher than that extracted in a cup of black tea.

QUALITY OF LEAF AND LIQUOR

The leaf of green teas should be olive green with no trace of brown or red colour. There should be an absence of white or yellowish stalk. The grade should be even in size, well twisted and clean, i.e., free from dust. Buyers for markets such as the Kashmir market attach much importance to the appearance of the leaf and generally prefer polished teas. For such markets the liquors are of less importance than the leaf appearance.

Liquors should be greenish yellow or lemon yellow, with no suspicion of redness due to withering or fermentation having taken place. The liquors should be pungent or "piquant" and should remain quite clear when cooled down. The case is directly the opposite with black tea liquors, which should "cream down" when cool. The infused leaf should be green with no suspicion of redness due to withering, fermentation or to discoloration of the leaf by red spider, mosquito or mechanical damage.

It is interesting to note that the weight of tea made from a given weight of leaf is less in the case of green tea than in the case of black tea.

One maund of black tea normally requires four to four and a half maunds green leaf.

One maund of green tea requires five maunds green leaf.

It is difficult to account completely for this loss in making green tea, though much of it is due to the extraction of soluble solid matter in the juice which is centrifuged off after steaming.

OOLONG TEAS—SPECIAL VARIETY

Oolong teas have a special market in America, and when of good quality command a high price. This fact induced the planters of India and Ceylon to make special investigation into the methods of its manufacture and Commissioners were sent from both these countries to Formosa, where the true Oolongs are made,

in order to find out all that could be gathered about the special manufacture on the spot. The results of these investigations were not encouraging, and the general conviction was established that the peculiar flavour of those teas was due to the special conditions of the soil and climate in Formosa. The Indian Commissioner gave it as his opinion that the flavour was due largely to the particular variety of the tea plant cultivated in Formosa. After all, the market for Oolong teas is a very restricted one, and has largely diminished in favour of black tea in course of time.

MANUFACTURE

The manufacture of Oolong tea may be described as a cross between that of green and black tea. The leaf is slightly withered before manipulation, and a light fermentation is allowed to develop before the tea is dried. In other respects the manufacture is practically identical with that of green tea.

CHAPTER XXI

BRICK TEA

TIBET TRADE

Brick tea is universally consumed in Tibet, hence the planters of India have made many efforts to capture the trade in that article, or at least to gain a footing in it. The Lamas of Tibet have this trade entirely in their own hands, and are very jealous of any interference by Indian planters, recognizing that anything like free trade in the article would mean a certain curtailment of their monopoly, hence they have thus far bitterly opposed and very effectually excluded the Indian article. No doubt in time some Indian tea will find an opening, and a trade be established by some equitable basis.

PRUNINGS

One of the difficulties in competing with the Chinese bricks has been the peculiar character of the article, especially the class of bricks which is most largely used by the great bulk of the population in Tibet. The fine grades of bricks made in China are practically just ordinary teas compressed into the form of bricks, but the coarse bricks which are used by the common people of Tibet are made from very coarse leaf and stalks, very similar to the prunings which are annually cut off the bushes by planters in India, and are destroyed or used merely as manure. It is manifestly very important that such material should be manufactured into tea, if a good market can be found for it. The price paid at present for bricks in Tibet would certainly be very remunerative if paid for Indian tea bricks.

COMMISSION TO CHINA

These considerations led the Indian Tea Association some years ago to despatch a Commissioner to China,

in order to learn on the spot the exact manner of manufacture; so as to be able to produce an article having the same flavour and appearance. Some valuable information was collected, which added greatly to the knowledge already in possession of certain planters both in Assam and Darjeeling. The Report* is a highly interesting record of travel in China. Some of the details of manufacture still remain a little obscure, although as a result of experiments an article very like the Chinese bricks is now being manufactured.

SEASON

It does not seem possible to make the proper stamp of brick from prunings only. The Chinese do not attempt it. They make their brick tea in the ordinary manufacturing season: chiefly in the province of Ssu-chuan; but in process of manufacture the fine leaves are set apart for the making of high grade teas while the coarse leaves, stalks and sticks are used for the production of rough bricks.

Brick tea can be made from leaf gathered under the system known as "breaking back" or taking the old tough leaves which have perforce to be left by the pluckers when the growth upon the business has been allowed to run away too long during the busy season. Leaves which are two or three months old are quite good for making this class of tea.

PANNING

The first process of manufacture is panning, which is done in the same way as already described for green tea. A little steaming previously is a great help to this process. No withering is necessary.

In the heat engendered by the panning, the leaves become a little soft, and they turn olive green in colour.

In practice a very efficient method has been found for wilting the leaf in place of panning. The result is fully as good and both the cost and the trouble are

* Report of a Mission to Ssu-chuan, by Jas. Hutchison, M.A.

greatly reduced. The leaf as it comes in from the field is passed through one of the automatic drying machines, now so common in all factories. The leaf is fed in thickly, and the machine arranged to go at its quickest speed. The temperature at first is about 160 degrees, but as soon as the first entered leaf begins to come out of the machine the temperature is put up to about 200 degrees. The leaf comes out of the machine in a very hot steamy state and perfectly wilted.

ROLLING

It is now passed to a rolling machine, in which it is rolled for about half an hour; the fibre of the leaves being well lacerated in the process, and all more or less broken. There is no curling, as the leaves are too coarse for this.

FERMENTATION—FUNGUS

Coarse leaf of this character does not seem to be capable of undergoing the fermenting process usual in the manufacture of black tea. It is substituted by an entirely different process. The leaf is placed in a heap upon a mat, or upon a cement floor, about six inches deep, or if the leaf is very dry it may be put two or three feet deep and covered with a sheet or tarpaulin; in which condition it is left for about five days. The heap generates a considerable amount of heat, and after about two days a black fungus begins to grow amongst it. This fungus is probably the chief agent in the progress of this class of fermentation, and determines the peculiar flavour which is characteristic of the true brick tea, and it also causes the peculiar black colour of the infused leaves. If weather is favourable, this process may be complete in four days; if cold and inclement, it may take as much as ten days.

DRYING

After fermentation is complete, the leaf is to be dried, either in the sun, or on *chulas*. The tossing over

in process of drying dispels the adhering fungus; and the leaf, being now dry, can be kept any length of time before moulding into bricks.

SORTING

Before being moulded, the tea requires to be sorted into two or more grades, and all foreign matter picked out. It is then treated with a thick starch, made from glutinous rice or a paste made from flour; after which it is steamed for about one and a half minutes, and immediately pressed into the moulds.

For the purpose of steaming the tea, the upper portion of an old updraft Sirocco Tea Drying Machine can be turned into a very effective steam chest. The top has to be covered over with sheet iron, and a steam pipe inserted at one side, to deliver steam from an ordinary boiler. Zinc bottomed trays are used, instead of ordinary Sirocco trays, and the quantity of dry tea for each brick or tablet is weighed for each tray before being passed into the machine. The steaming is sufficient while the trays are passed through cautiously.

MOULDING

The moulds used in China are 4 feet long, and 9¼ by 4¼ inches internally, with strips in the corners, to ensure the brick being rounded. These moulds are constructed so as to be detachable. The bulk of leaf, immediately after steaming, is rammed as tight as possible into the moulds; into which has previously been inserted a lining of fine bamboo mat. Each mould holds material for four bricks of about 4½ lbs. each. After each quota of 4½ lbs. a dividing piece of mat is inserted before the next lot is put in. A block of wood is put into the mouth of the moulds, and the whole keyed down very tightly. After about three days the bricks have sufficiently settled to allow of the moulds being opened out, and the bricks packed in paper, and put in the sun to be thoroughly dried.

MOULDING MACHINE

A hand-power brick machine has been found very suitable for moulding the tea into small bricks, or tablets. This is fitted with moulds to produce tablets, like tiles, about four inches square, and 1¼ inches thick, weighing ½ lb. of tea. One turn of the machine produces four tablets, and three men can turn out several hundreds of these tablets per day.

The brick which has been described is the ordinary tea brick used in Tibet; and over the greater part of that country it is used as corrency for barter of all sorts, and is a standard of value; but there are various sizes of bricks in use by the more wealthy inhabitants, the finer grades of tea being put up into smaller sizes of bricks. Tablet tea is no doubt also used; but is made in China chiefly for the Russian trade.

MOULDINESS

A most important fact to be noted is that the steaming and bricking up cannot be done in the winter season, and even the manufacture of the tea is difficult after the month of October. There is in the winter season a remarkable tendency for the tea to become mouldy before it can be dried after steaming; whereas in the summer season this difficulty hardly exists at all.

Recent investigations on the manufacture of brick tea have disclosed the following important points:—

Brick tea should have a very low tannin content and for this reason coarse leaf, containing perhaps 15 per cent tannin or less, is probably better for the purpose than fine leaf which may contain 25 per cent tannin or more.

Leaf from sections of tea uhich have been unplucked for 3 or 4 weeks or longer in the season, would provide suitable leaf for brick tea making.

Withering before panning is not essential and may be undesirable since it gives a chance for bruised leaf to ferment and cause liquors to be brown instead of golden in colour.

For the purpose of panning an ordinary tea drier run at 180 to 190°F. may be used. It should be run at such a speed that the leaf takes 15 to 20 minutes to go through, in which time, at the temperatures mentioned, the leaf is "killed", i.e., fermentative changes due to enzymes are checked. At the same time the leaf loses sufficient moisture to make subsequent rolling satisfactory. The moisture content should come down from say 77 per cent in the fresh, to about 50 per cent in the "panned" leaf.

The next process is really the "Silo" process used in farming. The rolled leaf is packed tightly in heaps, holes in the ground, or large boxes. Heat is generated and soluble tannin disappears. This is essential in order to reduce the strong astringency which would otherwise result in the tea owing to the presence of the soluble tannin. Experiments showed that two to four weeks was the time necessary to reduce the soluble tannin to a satisfactorily low level. The reason for the loss of tannin is probably that certain bacteria, of the type which develop in absence of air, attack the protein matter of the leaf, rendering it capable of combining with tannin to form a product insoluble in hot water.

During the "Silo" process fungus also develops on the leaf but this is not considered detrimental—rather the reverse. After this process, the leaf may need to be dried further before pressing into bricks. This drying can of course be done in an ordinary drier.

CHAPTER XXII

BUILDINGS

It is impossible within the scope of this book to go very minutely into the general details of building work all that can be done is to give a sketch plan of factory buildings, together with a few useful hints regarding preparation of materials etc., as suggested by practical experience.

SEASONED TIMBER—QUALITY OF TIMBER

When important buildings are in contemplation, it is very necessary to consider well before any definite plan is fixed upon and to take full advantage of the advice of firms in Calcutta who are experts in building as well as any available local knowledge or experience. All necessary timber should be sawn and stacked to dry one year before being used. The importance of having timber thoroughly seasoned is not so generally recognized as it should be, and in consequence there are many factories and houses with windows and doors as well as flooring boards, etc., in a permanently warped, ill-fitting, insanitary and unsightly state. With flooring boards it is advisable, even when the timber is seasoned, to put them down loosely for one year before fitting and permanently fixing them. All timber for permanent buildings should be of the best kind procurable; all posts, beams, door-posts, lintels, and rafters should be of the hardest timber, thoroughly dried and seasoned. Door and window frames and flooring boards may be of light but durable wood.

STEEL COLUMNS AND IRON ROOFS

Modern buildings, including factories, bungalows and even smaller erections such as hospitals and houses for Indian staff, etc., are generally built with steel

frames, or of reinforced concrete; roofs of corrugated iron or asbestos upon an iron framework, and insulated by a ceiling of some heat-proof material such as plaster board, Celotex, Tentest, etc.

FOUNDATIONS—CLAY AND SOORKEE MILL—BRICK MACHINE

Foundations should, whether possible, be of reinforced concrete, stone, or otherwise of well-burnt brick of the best quality, and should always be damp-proof, and constructed in such a way that damage by white ants to the woodwork above is prevented. Many tea estates in India require to have their permanent buildings of bricks because of the scarcity or expense of good stone; hence when an estate is commencing to build, it is worth getting a simple style of brick-making machine as well as a clay mill or puddling machine. The latter is a necessity where much building is to be done, and a brick machine also would probably pay itself in the improved quality of bricks which, being denser and much stronger than hand-made, enable the builder to construct his buildings of thinner walls, and so use less bricks.

PREPARATION OF CLAY—SELECTION OF CLAY

To make good bricks it is necessary in the first instance to get suitable clay, and to have it properly prepared. The clay soil should be dug up and watered some days before the final mixing takes place. In English brickfields this is done some months previously. If soil is dug up, watered, and made into bricks all in the same day, the result cannot be quite satisfactory, especially if all the operations are done by hand. After watering, the clay requires time to soak and "ripen". If there is a choice of soils for making into bricks, a good plan is to make samples and test them by burning in an ordinary fire.

VEGETABLE RUBBISH—EFFECT OF MANURE

When bricks are to be used in their sun-dried form only, a little admixture of vegetable matter does no harm, but if for burning, great care must be taken to exclude from the clay all roots of grass or other vegetable rubbish, because as soon as the bricks get red-hot in the kiln such vegetable matter gets consumed, and the bricks are in consequence more or less disintegrated. As an instance in point, on one occasion it was found that a large proportion of the bricks in a kiln crumbled away to powder in process of burning, although they had previously passed muster as well-made splendid-looking bricks. It ultimately transpired that the clay had been taken from ground upon which there was a heap of manure; this had been mixed in with the clay, and of course burned away whenever the bricks became red-hot. They made splendid *soorkee*.

MOULDING BRICKS

It is worth while to spend a little extra time and care to ensure bricks being well made. The clay should be well pressed into the corners of the mould, and the upper surface smoothed off carefully and smartly before the brick and the mould are separated.

DRYING

Before building into a kiln, it is of the greatest importance that the bricks should be thoroughly dry. If damp bricks are allowed to be built in, the whole thing may come to grief, and in any case there will be a great waste of fuel.

SIZE OF BRICKS

A very useful (and standard) size of brick is 10″ × 4¾″ × 3″, but the mould has to be made a good bit larger in order to allow for shrinkage in drying. About 11″ × 5¼″ × 3¼″ will dry to the right size. The

width requires to be rather less than half the length, so that two bricks placed sideways with a jointing of mortar between them, will equal one brick lengthways.

Smaller bricks make a more elastic wall, but they are more expensive to make and take more labour in building, besides requiring more mortar. Very large bricks are no economy, because many of them break in process of drying.

CONTENTS OF KILN

Some gardens making large quantities of bricks use a Bull's kiln, but the usual mode of burning bricks on a tea estate is to build a rough kiln or clamp of the bricks themselves in the form of a pyramid, similar to the accompanying sketch. If the length of the furnaces measures about 20 feet and the height of the kiln is made up of 27 courses of brick on edge, then a kiln consisting of 18 furnaces contains about one lac of bricks (100,000). This allows for some spaces here and there within the kiln which contain charcoal, coal, or other dry fuel, built in with the bricks. Smaller kilns can be made in proportion by having fewer furnaces.

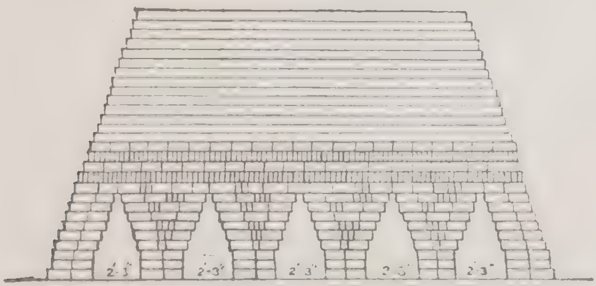


Fig. 17.—Brick kiln.

BUILDING KILN—BUILD LOOSELY

In building the kiln, the outer rows of bricks require to be carefully arranged, so as to ensure stability; it is a mistake, however, to arrange the interior bricks too

accurately, because a good deal of space must be allowed for smoke and steam to escape. Instances have been known of kilns very carefully built and fitted up, but when the steam began to ascend with the smoke it could not be carried out, and the whole upper portion of the kiln became a practically solid mass, which took weeks before the fire could penetrate it. If the interior is built quite loosely such a result cannot occur. The courses of bricks have to be built lengthways and crossways alternately, all on edge.

After all has been built, the outer surface, with the exception of the top, has to be plastered roughly with clay; this is allowed to crack in drying, so that through these many cracks some of the steam from the interior may escape, and the outer bricks, which are protected by the rough plaster, will also in course of time become thoroughly fired, although perhaps not so perfectly as those in the interior. The top of the kiln is covered with broken bricks, laid flat.

FUEL REQUIRED

When wood fuel is used, the quantity required is about 22 maunds, or 16 cwts., for every thousand bricks, besides about half a maund of charcoal built in. This is ample, and less will do if the fuel is of good quality.

FIRING—FIRE SLOWLY AND STEADILY—CLOSING FURNACES

Firing is usually done at both ends of the furnaces. If dry fuel is used, the firing must be done slowly, otherwise, the bricks surrounding the furnaces will be melted into glass before the heat has time to ascend far up the kiln. The reason for this is that clay is a very slow conductor of heat, and requires to have its own time. Firing must, however, be as regular as possible, because sudden and repeated heating and cooling tends to crack the bricks. For this reason firing has to be carried on continuously night and day until the work is done.

The progress of the heat may be seen at night by the red glow inside the cracks and joints of the wall, and during the day it can be tested by inserting a straw, which takes fire if the redness has reached the crack where it is inserted. When the redness has ascended to three-fourths the height of the kiln, usually 2½ to 3 days, the work is complete; the mouths of the furnaces are closed up with bricks and clay, and the kiln is left to itself. The heat then gradually ascends, and after two days the top of the kiln becomes red-hot.

COOLING

Cooling should be allowed to proceed slowly and naturally; the mouths of the furnaces are not to be opened for at least a week, as an inrush of cool air might crack many of the bricks.

SELECTION OF SITE FOR FACTORY

In choosing the site for a factory, many things have to be taken into consideration. It is well to be central, if possible, for the convenient conveyance of leaf from all parts of the estate. It must be on high ground, so as to avoid flooding. It is an advantage to be near a stream or other source of abundant water-supply, but must not on any account to be so placed as to be in danger of damage or obstruction from any possible change of the course of a river.

EXTRA SPACE—ROOM FOR ADDITIONS

There must be ample space of clear ground around the factory for the construction of accessory buildings, such as godowns, offices, workshop, etc., for the storage of a large quantity of fuel for machinery. The actual site of the building should be large enough to permit of additions and extensions in case of the area of tea being increased at some future time, or the leaf from some other garden being brought to it for manufacture, as a result of amalgamation.

FOUNDATIONS

In constructing a heavy building, the matter of first importance is the foundations. These must be wide and deep; not necessarily of the same depth everywhere, but must everywhere reach a substratum of hard solid ground if not actual bed-rock. The pits for foundations are to be carefully examined at every point before building is allowed to begin.

CONCRETE—PROPORTIONS—MIXING—BRICK CONCRETE

The accompanying sketch shows a section of foundation wall. At the bottom of the pit is first laid a bed of concrete, made of broken stone (small enough to go

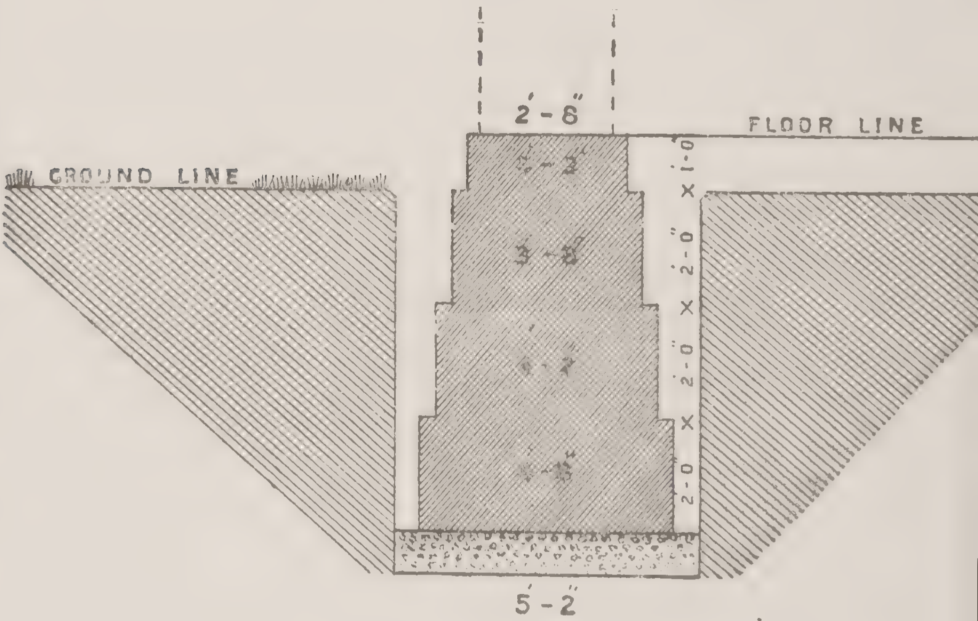


Fig. 18.—Foundation.

through a two-inch mesh), Portland cement, and sand. The proportions are six of stone, three of sand, and one of cement. If lime is good and cheap, one-and-a-half measures of it may be used instead of the cement. This should be all mixed together on the ground and slightly watered before being laid in the pit. It should be laid

about nine inches deep, well rammed down and beaten for two days. If broken brick is used for concrete, it must be first steeped in water, as it is so porous. The brick must be very hard—glassy kunker being best.

COURSES

The first course of the foundation wall must be considerably wider than the wall of the superstructure which is to be built. This is to be continued in regular courses narrowing gradually till the ground level is reached. A final course is now to be laid with more care, the outer edges being dressed perfectly straight and the top made perfectly level, and finished off about one foot above the level of the ground.

DEPTH AND WIDTH

The width of this upper course of the foundation requires to be at least six inches greater than the thickness of the wall to be built upon it.

BED

About 6 feet is a good depth for foundations, provided that the ground is solid, with no part of it "made earth" recently filled in. The width at the bottom may be double the width or thickness of the wall of building to be constructed. If at this depth the ground is still soft or unstable, the foundation must be made deeper and wider as necessary. A rocky bed is of course the most satisfactory.

THICKNESS OF WALLS

Brick walls are usually described as so many bricks thick; thus, if the bricks are 10 inches long, a two brick wall would be 21 inches, allowing for irregularities and for mortar joints.

SPACE FOR MORTAR

A good strong wall for a factory can be built three bricks thick, about 31 inches, or 32 inches if the bricks are uneven. This allows plenty of space for mortar, which is very important. If bricks are placed quite closely together, there is great probability that many of the joints will get no mortar at all.

BRICK LAYING—BINDING

There are several systems of laying bricks. The most common way is to lay *stretchers* and *headers* (lengthways and endways) alternately in the same course. The important point is to see that the headers of each course are placed over the centre of the stretchers of the course immediately below it, and that the stretchers are laid so as to cover all the joints and so bind the wall. Whatever system is adopted must be adhered to throughout, and the pattern formed on the wall by the joints should appear uniform and symmetrical.

MORTAR

Mortar should be thoroughly well mixed. Nothing does this so well as a pan (or soorkee) mill, but if done by hand, some pains should be taken to see that it is done well.

CLAY MORTAR

For small or unimportant buildings clay is often used as mortar, and is indeed much better than lime mortar when the lime is of inferior quality.

SAND

For all heavy and important buildings, such as a tea factory of more than fifty feet width, the very best materials must be used. The lime used should be freshly burnt and newly slaked. If sand is at all earthy, or mixed with organic matter, it is quite unsuitable for mortar, and even if such sand is mixed with the very

best lime, the resulting joint is as soft as clay. River sand is better, but is not quite satisfactory, because all river sand is water-worn and is too smooth to allow of the lime taking a good grip of it. The only way to obtain really good sand is to take a piece of sand-stone and break it down with a hammer, then sift it.

Sand which is to be used for mortar should invariably be washed, in order to get rid of earthy matter. This can be done by constructing a trough in a place where a constant stream of water can be led into it.

SOORKEE

Soorkee (powdered brick) is considered superior to sand for mortar and should be used exclusively wherever there is any doubt regarding the quality of the sand obtainable. Wherever there is a brick-kiln there will be a supply of *soorkee* obtainable from broken or badly formed bricks; but if mortar is wanted for some stone work only, and no bricks are being made, a very simple and efficient mode of making *soorkee* is as follows :—

SOORKEE BRICKS

A number of reeds, stalks of elephant grass or sticks, are collected and cut into lengths of 12 inches. A piece of clay is wrapped round each, so as to make it look like a baker's rolling pin. After drying in the sun, these are collected and built into a small kiln and burnt. The burning is easy and expeditious, because the stick through the centre of each brick assists the progress of the fire, and the result is satisfactory. These little bricks are easily broken and powdered down into *soorkee*.

PROPORTIONS FOR MORTAR

The proportions in the different classes of mortar are as follows :—

	No. 1	*No. 2*	*No. 3*
Lime	1	1	1
Sharp sand	1	1	...
Soorkee	2	1	1
Total parts ...	4	3	2

No. 1 is ordinary mortar; No. 2 is very good; while No. 3 is very strong, and only used for special work.

GOOR

Native builders have for many years used *goor* (raw sugar) in mortar which is required to be specially strong; its effect is excellent and is due not to mere stickiness, but to a certain chemical action which the sugar exerts upon the lime, rendering it much more tenacious and effective. Goor should always be used in the mortar for arches.

STEEPING BRICKS

All bricks must be steeped in a tub of water before being laid on the wall, otherwise the mortar will not adhere to them. This is an important matter which must not be overlooked if the building is to be satisfactory.

THIN MORTAR

The mortar has to be made quite thin, and baled on to the wall like soup, so that it runs into every crevice of the joints; the process being repeated until all the joints are well filled up. The mortar thickens in a few seconds after it is put on the wall.

THICK MORTAR

A thick layer of mortar on the top of each course should not be allowed—only enough for smoothening the unevenness of the surface is required. The courses of bricks should touch at some points.

PLUMMET

It seems hardly necessary to mention that every course of a wall should be raised perfectly plumb with those below it. The plumb rule is unknown to native workmen, but they use a plummet of simple construction

(usually made from a door handle), which can be fully as effective, and much more suitable to their ways of working. The bulb of the plummet should always be applied to the lowest course, and each course as it is laid has to be tested and made plumb with the bottom one.

UPPER WALLS

Above the first floor the wall may be reduced in thickness, and again above the second floor. The upper walls have less to carry, and do not require so much strength.

CONCRETE AND REINFORCED CONCRETE

Of recent years reinforced concrete has come to be very widely used in India, not only for building purposes, but for posts carrying electric cables and telegraph wires, fencing posts, drains, culverts and bridges, and many other purposes.

The cement now sold in India is of excellent quality for building, etc., and the Concrete Association of India is always willing to supply any information required in regard to details of construction where cement is used. This Association has published many very useful pamphlets, such as "The Elements of Concrete Making", "Concrete Floors and Footpaths", "Concrete Masonry Construction", etc. It also publishes a monthly paper "The Indian Concrete Journal". Concrete itself is a mixture of Portland cement, sand, stones or crushed rock, and water, which sets when left in a mould and becomes hard like stone. The setting and hardening is due to chemical action between the cement and water and it takes time for this action to reach completeness. Thus well-made concrete, unlike many other building materials, strengthens with age. In order to get the best results great care and attention to detail is necessary in preparing the mixture. Quantities must be measured carefully, and mixing must be efficient. The following

are recommendations made by the Concrete Association :—

THE MATERIALS

The Portland cement must conform to certain specifications laid down by the British Engineering Standards Association. Any doubts as to the quality of cement must be settled by analyses and tests. Cement must be stored in a dry place, preferably stored off the floor of a godown, on a wooden platform.

Sand, or fine aggregate. This must be clean and especially must be free from organic matter, loam, clay, shells, soft or flaky particles. It should all pass a ¼ inch screen; all but 10 per cent pass a ⅛ inch screen; not more than 20 per cent should pass a 50 mesh screen, and not more than 3 per cent pass a 100 mesh screen.

Stone, or coarse aggregate. This consists of clean pebbles, broken stone or gravel not smaller than ¼ inch size, and not larger than 2½ inches. In ordinary reinforced concrete work the coarse aggregate should not exceed 1 inch in size.

Water must be clean and free from oil, alkali or acid. Water fit for drinking is suitable for concrete work.

PROPORTIONS

These vary according to the class of work to be done. For ordinary reinforced concrete buildings 6½ gallons of water go to one sack (110½ lbs.) cement. The proportion of fine and coarse aggregate varies again according to the kind of work, and the table below, quoted from the Concrete Association's pamphlet "A General Specification for Portland Cement Concrete", is a useful guide.

If the first batch of concrete is too stiff, or lacks smoothness and workability, the next batches should be made up with slightly altered proportions of fine and coarse aggregates. *Extra water should not be added*, as this reduces the strength of the material. If the concrete

is too wet, more aggregate should be added. The maintenance of the right cement-water proportion according to the class of work is most important.

TABLE III

Kind of work.	Trial mix for first batch: Cement.	Aggregates: Fine.	Aggregates: Coarse.	Maximum size of aggregate.
	Sack.	Cu. ft.	Cu. ft.	Inches.
Foundation walls, which need not be watertight, mass concrete retaining walls, etc.	1	3½	6	2½
Watertight basement walls, silos, dams, etc.	1	2½	3½	1½
Water storage tanks, well curbs, floors, roads, pavements, piers, columns, posts, sills, lintels, etc.	1	2	3	1
Very thin sections and fence posts and other small concrete products.	1	2	2	¾

MIXING

The sand and cement are first mixed together, then the coarse aggregate is mixed in and finally the water, sprinkled from a watering can fitted with a rose over the whole mass with continuous stirring of the mass. The concrete should be placed in position for setting as soon as possible after addition of water and thorough mixing.

CURING

After placing the concrete it should be protected by sacks or other covering for 24 hours, and then kept

wet by covering with water or by spraying at intervals, for at least 14 days, except in the case of rapid hardening cement which needs only 7 days' watering.

REINFORCING

The reinforcement of concrete for buildings, etc., depends naturally on the style of work and strength required. Steel rods, angle, T and H iron, expanded metal, metal strip, chicken and rabbit wire are commonly used for various types of reinforced work.

The steel rods for reinforcing require to be arranged differently for different classes of work. When there are piers in the walls, the main rods are placed horizontally, from pier to pier. Main rods might be ½ inch diameter, subsidiary rods ¼ inch. The subsidiary rods in this case are placed vertically, at intervals of 18 inches, and interlaced where convenient with the main rods, which are from six to nine inches apart.

If there are no piers, the main rods are placed vertically to reach from floor to floor, and the subsidiary rods horizontally.

PARTITION WALLS

The rods are arranged preferably 1 inch from each surface of the wall and not in the centre of the thickness; then a board framing is set up to form a trough about 12 inches high, and the thickness of the required wall. The concrete is then rammed in and well beaten down. The trough arrangement is moved up as the concrete hardens, keeping always perpendicular. When long buildings of concrete have to be erected it is advisable to have partition walls in the interior, binding the main walls together at intervals as frequently as may be practicable.

COLUMNS

In building columns, the general rule is to give a reinforcement of steel measuring 1 per cent in the section

of the column. A column of 9½ inches requires to have four main rods of ½ inch steel placed vertically. These are bound horizontally at intervals of 9 inches, with thick wire, or ¼ inch rod iron.

Such a column 10 feet high, is reckoned to bear with safety a load of 12 tons or more.

UPPER FLOORS

For concrete upper floors or roofs, the most convenient material to use for reinforcement is expanded steel. Concrete beams should not be attempted unless under the direct supervision of an expert. If the floor is supported by steel beams or girders, these must be sufficiently strong to ensure that there will be little or no deflection, otherwise there would be danger of the cement floor cracking. When the girders have been placed in position a temporary plank-flooring is to be arranged between the girders, so that the upper surface of the planks will be in line with the lower edge of the upper flange of the girder. The expanded steel is now laid from girder to girder.

For an ordinary floor, say 4 inches thick concrete, the expanded metal is ordinary $\frac{1}{4}'' \times \frac{1}{8}''$ metal and $8'' \times 3''$ mesh.

The concrete used for this work should be a little stronger than that used for walls, and may be 4, 2 and 1 parts of stone, sand and cement, respectively.

The concrete is spread over the expanded metal to a depth of 4 inches, and well beaten down. It is sometimes advisable to have embedded near the surface of the floor a strip of the expanded metal, say 2 feet wide along the line where each girder occurs, the strip running in the same direction as the girder.

A floor of this description, with the girders 9 feet apart, will safely bear a load of one cwt. per square foot.

STEEL COLUMNS

No steel columns should be constructed within concrete walls, as has already been done in some cases

by inexperienced persons, unless these are well embedded in concrete all round, otherwise they may become a source of weakness instead of strength.

Concrete walls should be continuous, without a break of any kind. Steel columns may, of course, be used for supporting floors, instead of the concrete columns above described, but will be much more expensive.

ROLLING AND FERMENTING ROOM FLOORS

Special care is required in the laying of floors for rolling and fermenting rooms, in view of the need to keep these floors scrupulously clean. It is essential to use a cement which does not effloresce. Some Indian cements, when laid and cured, exude a white salt which is mainly composed of carbonate of soda. This is very harmful to fermenting leaf, as it is strongly alkaline. Good English cement does not effloresce in this manner.

The following recommendations are made with a view to getting a hard, glassy durable surface which will not pit, crack or flake away under treatment.

BASE OR FOUNDATION FOR FLOOR

The base, on well compacted earth, should be 4 inches thick; the softer the earth, the thicker should be the base or foundation. The proportions for this base are four parts of stone, two of sand and one of cement. After the base has set, the surface should be moistened preparatory to laying the surface, but pools of water are to be avoided.

A thin paste of pure cement is brushed over the surface of the base, treating an area of about 100 square feet at a time, and applying the surface layer *within half an hour.*

SURFACE OF FLOOR

The surface layer should be not less than ¾ inch thick, preferably one inch, and consists of a mixture

of $1\frac{1}{2}$ parts of stone ($\frac{1}{8}$ inch to $\frac{1}{4}$ inch size), one part sand and one part of cement. It is not advisable to use pure cement for the surface layer, and it is not advisable to work the surface more than absolutely necessary while smoothing off irregularities. A light tamping down, followed by a quick smoothing with the trowel gives the best results. Too much working results in water and fine particles coming to the surface, causing a porous floor. After 24 hours' setting the floor should be kept flooded with water for 14 days, changing the water every day or two.

POLISHING

The polishing is a most important process for rolling and fermenting room floors. The first polishing is with a medium grade carborundum brick. After this any blow-holes, etc., should be filled in with pure cement paste and the floor again kept flooded for 7 days. Further polishing, first with the medium and finally with the fine carborundum bricks, is continued till a glassy finish to the surface is obtained.

FACTORY DESIGN

There is a wide variation in style and design of factories in different parts of North-East India. A great number are old buildings, and having originally been made for a much smaller crop than that made at present, have been added to here and there from time to time. In these factories, the fermenting room is generally found separate from the main building often occupying part or the whole of the ground floor of a withering house.

In the hills and in the Dooars many factories are more than one story high and withering racks occupy the stories above ground. In Assam and the Surma Valley this type of factory is seldom seen, and "overhead" or "loft" withering is not generally favoured. In the hills were incessant mists occur during the rains, loft withering and the use of warm air from the factory

are generally regarded as essential, apart from the fact that in hilly situations there is a dearth of level ground for building separate withering houses.

There are certain important points to consider in building a factory. A certain balance must be struck between what is economically possible to do in the structural line, and what is the best lay-out for economy of working and production of good quality.

Attention must be paid to coolness of fermenting and rolling room. This involves adequate insulation from the drying room. In some factories the drying room is separated by a passage 4 to 6 feet wide, in others a double brick wall separates the rooms. The lay-out of a factory in Assam making 10,000 maunds tea is shown in the accompanying rough diagram.

The fermenting and rolling rooms are one, and the temperature can be controlled to a large extent in this room by good insulation of walls and ceiling, good ventilation, and the use of mist chamber or humidifiers. Along the south side a row of low trees or shrubs, or creepers growing up a bamboo or wire netting frame would help greatly to shade that side of the room from the sun.

The design of the factory is such that there will be the minimum of crossing by operatives taking leaf or tea from one process to the next, and this makes supervision and systematization of the work in the factory a much simpler job.

CLEANLINESS IN THE FACTORY

In order to make the task of cleaning the factory easier, and to reduce the risk of foreign matter getting into the tea there are one or two useful points to observe in laying out a factory. All iron columns should be cemented up to a height of 6 feet, and thus converted into round smooth pillars; the angles between pillars, walls and floors should as far as practicable be rounded off with cement, as is done in most modern houses and bungalows.

The under surface of corrugated iron roofs should be painted with aluminium paint to prevent flakes of the galvanizing material from falling onto floors and machines. Nowadays, in most factories, machinery and ironwork are painted with aluminium or some other lead-free paint of a light colour and this often makes a wonderful improvement in the lighting of the rooms.

It is a very useful idea to have small boxes fixed on pillars and near machines, for the reception of any foreign matter found in the leaf or tea. The factory staff soon learn the habit of picking out *jabra* and placing it in boxes if these are conveniently to hand.

LEAF HOUSES

The leaf houses for withering require to be convenient to the main building. They are usually made with the sides quite open, but with some arrangement of movable louvres, mats or blinds to shut off the direct rays of the sun or to exclude rain and wind necessary.

CHUNGS

The old style of leaf house usually has two floors. Between these floors are erected *chungs* of bamboo work or battens, covered with hessian cloth. The *chungs* are about 3 feet apart, to give just enough space for boys to creep in and spread the leaf, and they are erected over the whole floor space, with the exception of a passage down the centre running the whole length of the leaf house.

WITHERING RACKS

Some factories have their leaf houses fitted up with frames, with either wire mesh or open woven hessian cloth. This is a better plan as it economizes space, and it gives the factory manager or assistant an opportunity of inspecting the leaf spread at every point without having to creep under a three-foot *chung*. The one thing to be specially guarded against is putting the tiers of wire or cloth too closely together; they should be not less

than 9 inches apart; 12 inches is a good distance as there are no fans in these houses to circulate the air.

A few factories in Assam which had adopted the system of wire withering racks have gone back to the *chungs*. Both systems have their advocates, and it may be assumed that in a fairly dry climate the racks are suitable, but in any district where withering is difficult on account of frequent and heavy rain the open *chungs* are more effective.

Before erecting a leaf house, note should be made of the prevailing direction of the wind during the manufacturing season, and the house erected so that the wind shall blow across the house and through between the frames or *chungs*.

FIRE

The loss of a tea factory by fire is, of course, a very serious matter, especially if the disaster occurs at a busy time, and if there is no other factory in the neighbourhood which can be got to manufacture the tea. Fire hoses may be of some use on the outbreak of fire if there is a good head of water and if the matter is taken in hand promptly; but anyone who has seen a large building in England ablaze, with a dozen hoses playing upon it in vain, can realize how hopeless it is to attempt to put out a big fire with one or two hose pipes after the fire has got fairly under way. The planter must depend more upon caution and care in preventing the occurrence of fire than upon measures for putting it out, although the latter are certainly not to be neglected.

FIRE EXTINGUISHERS

Chemical fire extinguishers can with advantage be placed at various points in the building especially in the withering lofts. These are of great use in case of fire from a short circuit or the upsetting of a lantern, or similar accident, provided it is discovered at once. The "Minimax" Extinguisher has much in its favour.

NAKED LIGHTS

In most factories nowadays, lighting is by electricity, though some still rely on lamps. Where the electric light is in use, there is less danger of fire, but even with it there is necessity for precaution in fixing up and arranging the wires, so that in case of fusion, which sometimes does take place especially in old, or neglected installations, there would be nothing combustible at hand to catch fire. Safety plugs are of course necessary for all electric plant.

LIME WASHING—DRIERS ON FIRE

In old wood-structure factories a great help against fire is to have the underside of rafters and battens white-washed with lime, especially those just over drying machines. It sometimes happens that fine fluff collects in the air tubes of a drier, and if the tubes get red-hot, this fluff takes fire; the fire is carried to the tea in the drying chamber, and by the action of the fan within the machine the whole thing is soon in a blaze. It is obvious that the air tubes should be cleaned out periodically so that no fluff is allowed to collect in them, and in that case no fire can reach the tea.

NIGHT WORK

Night work should be avoided if possible, every effort being made to start work very early in the morning and get the day's work over before dark.

THATCH

Thatch roofs are always dangerous and should not exist within a hundred yards of a factory.

HILL FACTORIES

On hill gardens, the factories have to be made to suit their circumstances. In many instances the choosing of a site is not an easy matter. Water-power is the first consideration if it can possibly be obtained. The build-

ing must be in a secure place however. Instances have been known when a factory has been carried away bodily in a night by a stream changing its course. It sometimes happens that a certain portion of a factory is liable to be inundated and actually silted up more or less during heavy spells of rain.

NATURAL SITE—TRANSIT

It is very seldom that a site for factory buildings can be obtained without levelling down to some extent; but a natural site should be chosen, if possible on secure ground and in a convenient place. It must be near the coolie lines so that the labourers may not have far to go home after bringing in their leaf. It should also be convenient to the houses of manager and assistants. It is well also that the factory should be at a convenient place from which the manufactured tea can be taken to the railway; this is not so important, however, as the carriage of leaf to the factory, because it takes four maunds of leaf to make one maund of tea, and the carriage of leaf is heavier in that proportion.

LEVELLING SITE—SLOPE INWARDS—DRAIN

In levelling the site for a building, the natural condition of things becomes altered, especially as regards drainage. The vegetation is carried away and the soft surface soil is removed, so that all the water, which would formerly have soaked into the earth, now flows over it, seeking some means of escape. If the site were made absolutely level—this water would flow away equally at all points, but in practice such water finds out a depression, and the whole soon tends in that direction, and makes for itself an ever-deepening water course. If the water is allowed to collect and flow over a bank of made earth, half an hour of heavy rain is sufficient to play appalling havoc. For this reason, a new site must be made to slope *inwards* (as shown in sketch) so that all water will flow towards the hard ground where a drain

must be made to receive it. This drain must be continued so as to carry away the accumulated water and deliver it at a safe place where there is a natural outlet.

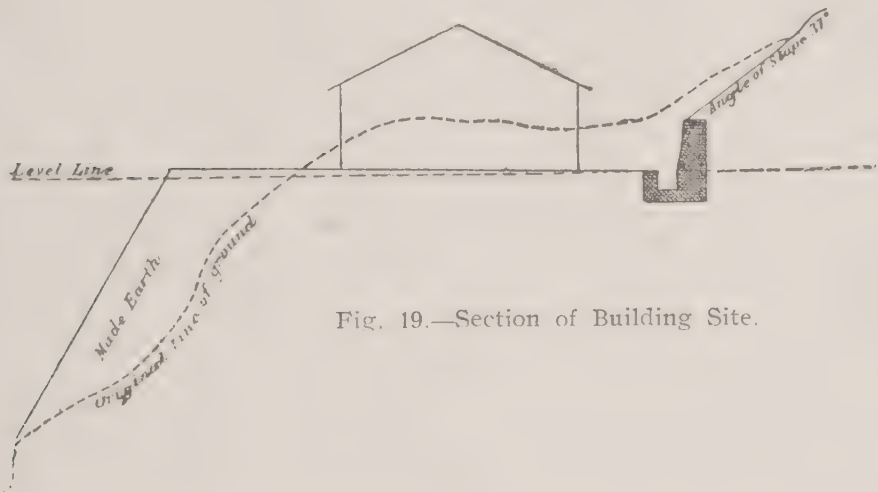


Fig. 19.—Section of Building Site.

For levelling sites for buildings the instrument known as Bald's Self-registering Clinometer is very useful; it can be operated by any one for work of this kind without any special knowledge of surveying.

The bank of made earth is to be left especially high the first year, to allow for settling down after it gets wet.

MADE EARTH

Whatever buildings are put up must be on the hard ground. On no account must a wall be built upon made earth.

ANGLE OF SLOPE

The bank which has been cut into, if composed of soft earth, must be sloped off above the site so that the angle will not be greater than 37°, which is considered a safe slope for an earth bank. If the angle is greater than this, it must be strengthened and altered to this slope by a masonry revetment.

If a site is liable under any circumstances to damage by landslip from above, it is not a suitable place for building upon.

SMALL SITES

One of the most common errors hitherto made in levelling sites, has been in leaving them too high and small, whereas another two or three feet cut off would have resulted in much more space. This work is, of course, very expensive, but if permanent buildings are to be put up, the work of levelling is done once for all, and it can never be improved or done over again after the buildings have actually been erected.

PLANTING SLOPES

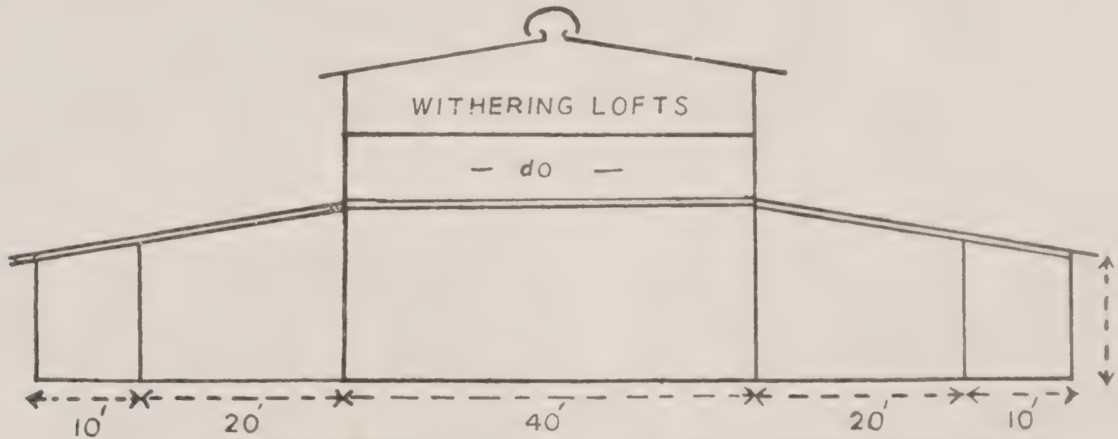
Any moderately steep slopes above a building site should be turfed and planted with deep-rooting trees or shrubs. They should not be cultivated or anything done to loosen the soil, which might produce a landslip.

ROOM FOR EXTENSIONS—COSTLY TERRACES

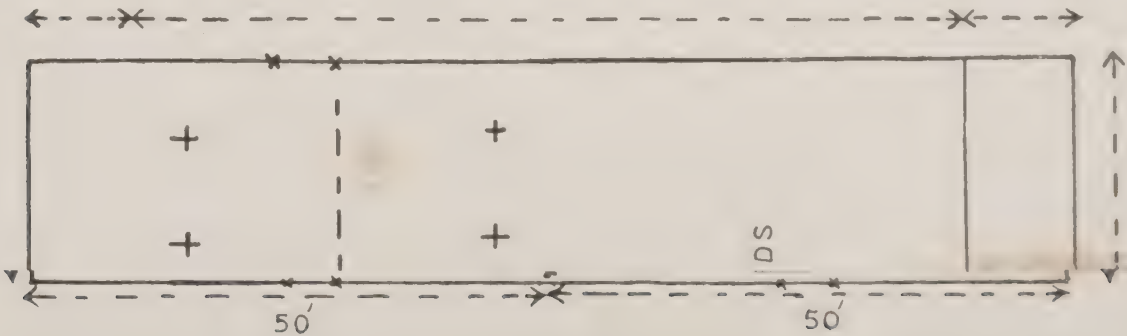
A site should, if possible, be chosen which will be capable of extension at some future time for additional buildings if necessary. A very common error in the past has been to begin building upon a site which was naturally too small, and in course of time, as extensions have become necessary, various buildings of an unsuitable nature had to be built upon huge terraces supported by costly revetments. It is better to go to the expense and trouble of selecting and cutting a good large site at the start.

COMPACT BUILDINGS

It is well, if possible, to have but one building for manufacture; but sometimes the nature of the ground does not permit this. The important point is to have the buildings as compact as possible.



SECTION THROUGH ROLLING AND FERMENTING ROOM



CHAPTER XXIII

MACHINERY

So much might be written regarding machinery for a tea estate, that to deal with it fully would require a separate volume. The intention here is to give a few practical hints which may be useful for planters who have not had special training in this line.

SPECIAL KNOWLEDGE NECESSARY

The use of machinery in tea factories has so much developed of late years that a special knowledge of the subject has become of great importance to both Manager and Superintendent. There is the question of choosing the best kinds of machinery from time to time, as required, as well as the proper measures to be taken for the care of engines, boilers, etc., so as to make them do the full tale of work with the minimum of fuel and yet live as long as possible. Until comparatively recent times water-power and steam were the only two sources of power used on tea estates, the former chiefly on hill gardens and the latter in the plains. Nowadays Diesel oil engines have to a large extent replaced steam. In Sumatra and Java hydro-electric power is used to a considerable extent, but is very little used in North-East India.

WATER-POWER

A factory is happily situated when it has water-power available on the spot. The saving in fuel is enormous, being about 65 per cent of the total quantity otherwise required. When the working parts are driven by water-power, the only fuel required is the quantity necessary for the furnaces of drying machines, and perhaps for heating the withering lofts occasionally.

The most effective way to utilize water-power is b turbine.

TURBINES

Turbines can be had suitable for high or low fall The higher the fall, the less volume of water is require If a turbine proves incapable of the amount of wor required of it, the fall may be added to, and addition power thus obtained, provided always that the turbi has been constructed to stand the extra pressure whic a higher fall entails.

If there is a sufficient volume of water obtainab a large turbine with low fall and moderate speed is bes because there is much less wear and tear, besides le fear of a break-down.

PELTON WHEELS—SCREENING

For a very high fall, the Pelton Wheel is perhap the best motor, as it does not suffer so much from frictio as the ordinary turbine. For all classes of turbines wat requires to be carefully screened at the source, an should also pass through one or two settling tanks befo reaching the main tank to which the turbine pipe attached. When tanks are constructed of masonry they require to be very strongly built, in order to resi the pressure of water, and to ensure that there shall b no possibility of leakage. Each tank requires to have sluice door at bottom level, for the purpose of periodica scouring out.

FRICTION

The purifying of the water is of special importanc in the case of a very high fall, when the least admixtur of fine sand grinds away the core of the turbine wit remarkable rapidity.

HAULAGE

Sometimes a factory is so situated that water-powe is not available on the spot, but can be had at the distanc

of perhaps half a mile or more below the site of the factory. A turbine has sometimes been made use of in such cases, and the power transmitted to the factory by means of wire ropes carried upon pulleys.

FRICTION

Up to a distance of 2,000 feet this system has been found to work very satisfactorily, but beyond this the loss of power by friction becomes too great. It has been ascertained by actual experiment that for an installation of one thousand feet distance, about ten per cent of the total power is absorbed in overcoming the inertia and friction of rope and pulleys alone, when unloaded.

For carrying the rope, the driving pulleys require to be packed with hard wood. It is important, however, that the groove in the pulley for receiving the packing shall be rectangular; so that in case the rope wears its way to one side of the pulley, it will still be bearing directly upon the wood packing.

Carrying pulleys are better not to be packed at all.

For ropes conveying 60 to 100 horse-power, the speed should not be greater than 2,000 feet per minute. A very high speed soon wears out both ropes and pulleys. It is well to have the installation fully fifty per cent stronger than the circumstances require, because when run at full power there is considerable slipping of the rope; which causes very soon wear and tear.

COMPRESSED AIR

Another means of transmitting such power is by compressed air, but it has probably not been sufficiently tested in connection with this kind of work.

ELECTRICITY

The best means of transmitting power is undoubtedly electricity, which is largely used in the Dutch East Indies, by factories which are within a few miles of any of the haunts of the "Water Giant". On some estates

in North-East India an arrangement of this sort ha already been constructed and is working satisfactorily the two chief hindrances to its being generally adopte are the first cost of the installation and the want of practi cal knowledge necessary for running an electric powe scheme.

STEAM ENGINES

The steam engine held the field for many year on the great majority of tea estates and is still ver popular in many companies. The best type of engine are cheapest in the end. This does not mean the mos expensive or the most complicated engine but on produced by a firm which can be relied upon to suppl a thoroughly good article, well balanced and carefull fitted in every detail.

COMPOUND ENGINES

In the case of small engines, the simpler the styl of construction the better. A compound engine shoul not be thought of unless it is to be of 20 horse-power o over.

BEDDING

Engines, and indeed all heavy machinery whic is subject to vibration, need to be bedded on concrete and fixed with holding-down bolts, whose heads ar well buried in the concrete, so that the whole frame i held perfectly rigid.

BOILERS—WATER-TUBE BOILERS

In large factories, the steam required may be generated in large stationary boilers. Two or more improved Cornish boilers make perhaps the most simple and efficient arrangement. They should be arranged so as to be capable of being coupled together, or used singly. When the factory is in full operation, it is best to have the boilers coupled together, as the pressure can

then be kept more uniform. Where fuel is scarce and expensive, water-tube boilers are best.

All persons who have anything to do with the working of steam boilers, do well to note that a considerable responsibility attaches to them. In England there are very strict laws and regulations regarding the ownership and working of such boilers. In Bengal, and Assam also, the most stringent regulations have been introduced by the Government, ensuring constant supervision by officials appointed or approved by Government, chiefly at the expense of the users themselves.

ACCIDENTS

As boilers become older, the liability to accidents becomes much greater, and it is in the interests of the users themselves to see that they are worked with the greatest care, and to take such precautions as will ensure the longest life possible for the boilers, and the greatest efficiency during that life. It should be borne in mind that an enormous quantity of fuel may be wasted every day, and a great deal of power constantly lost, by want of proper attention to the simple rules which ensure cleanliness, efficiency, and permanence.

BLOWING OFF

Boilers require a great deal of care and attention, especially if the feed water is at all dirty. Sediment naturally settles down, hence the blow-off cocks should be opened for a time every day when the boilers are under steam, when the dirtiest of the water and a great deal of sediment will be cleared out. The cocks should be kept full open till the water in the gauge glass is depressed about two inches. If the feed water is very foul, some water should be blown off several times each day. The boiler should also be emptied once a week and the interior washed out before refilling.

INCRUSTATION

While a boiler is in active operation an enormous quantity of water is evaporated into steam, the water only being taken, and the impurities which had been held in solution are left as a deposit. This change is most active at the inner surface of the boiler tubes, the point where the heat of the fire passes into the water. One result is the formation of a hard film, or scale, all over the tubes, and in a less degree on all other surfaces in the interior of the boiler. This scale is largely heat-resistant, and soon reduces the efficiency of the boiler, causing a great waste of fuel. There are various chemical compositions which to a large extent prevent the formation of scale, and which can be introduced regularly without difficulty.

SLUDGE DOORS

Periodically, at least once or twice in the season, boilers should have all sludge doors taken off and be thoroughly cleaned out.

SAFETY VALVES

Safety valves should be kept in order and arranged so that steam will escape whenever pressure becomes too high. According to Government rules, the safety valve is considered the most important fixture of a boiler. There must be not less than two of these on each boiler, one or both being locked, in order to prevent any tampering with weights or springs. These valves require also to have attached to each a lever, by which the weight or spring can be eased up by hand occasionally in order to test its efficiency. The reason for this precaution is that in some instances safety valves which had never been operated for many years became so jammed by rust or incrustation as to be perfectly rigid, and explosions were traced to this cause.

GAUGE GLASSES

Test cocks and gauge glasses should be kept clean and in working order. The water in the gauge glass should gently rise and fall in sympathy with the boiling of the water inside the boiler; if the water in the glass is perfectly still, there is reason to suspect that the passage has become blocked, and the cocks must be opened at once in order to test this.

FUSIBLE PLUG—DAMAGED PLUG

A fusible plug is placed in the fire-box of every boiler as a precaution against explosion. If by any want of care on the part of the fireman, the water in the boiler becomes very low, the plates of the fire-box soon become red-hot. If this is allowed to become much developed, an explosion may result, especially if water is suddenly introduced when the plates are red-hot. The fusible plug is so constructed that it melts away whenever the plates begin to get too hot, and the hole thus made allows a jet of steam to escape into the fire, with the object of putting it out. If a plug becomes partially melted or damaged, it is evident that the water has been too low; a new plug of the same kind must be inserted in its place. On no account should a solid plug of iron or brass be screwed into the hole.

LOW WATER

If by any chance the water has been allowed to fall so low that nothing but steam can be got from gauge glass or test cocks, the fire must be damped at once and water admitted cautiously.

STOKING

The furnaces should be supplied with fuel in small quantities at frequent intervals. The attendant should take note of the progress of the work inside the factory and stoke the furnaces in such a way that when the engines are stopped there will not be an excess of steam,

and the furnaces will not be full of fresh fuel. In the case of large boilers great economy in fuel can be effected by attaching mechanical stokers to the furnaces.

WOOD FUEL

When wood fuel is used, it is most important that a sufficient supply should be laid in for the whole year before the season commences; also that the wood should be perfectly dry. If green or wet wood is used, fully double the quantity will be consumed, and even then it will be difficult to keep up steam when the factory is in full operation.

STOCK OF WOOD FUEL

For the boilers a stock of wood should be laid in equal to fully four times the weight of tea for the season; and for the drying machines two times, making a total of six or even seven maunds of wood to every maund of tea.

EMPTYING BOILER

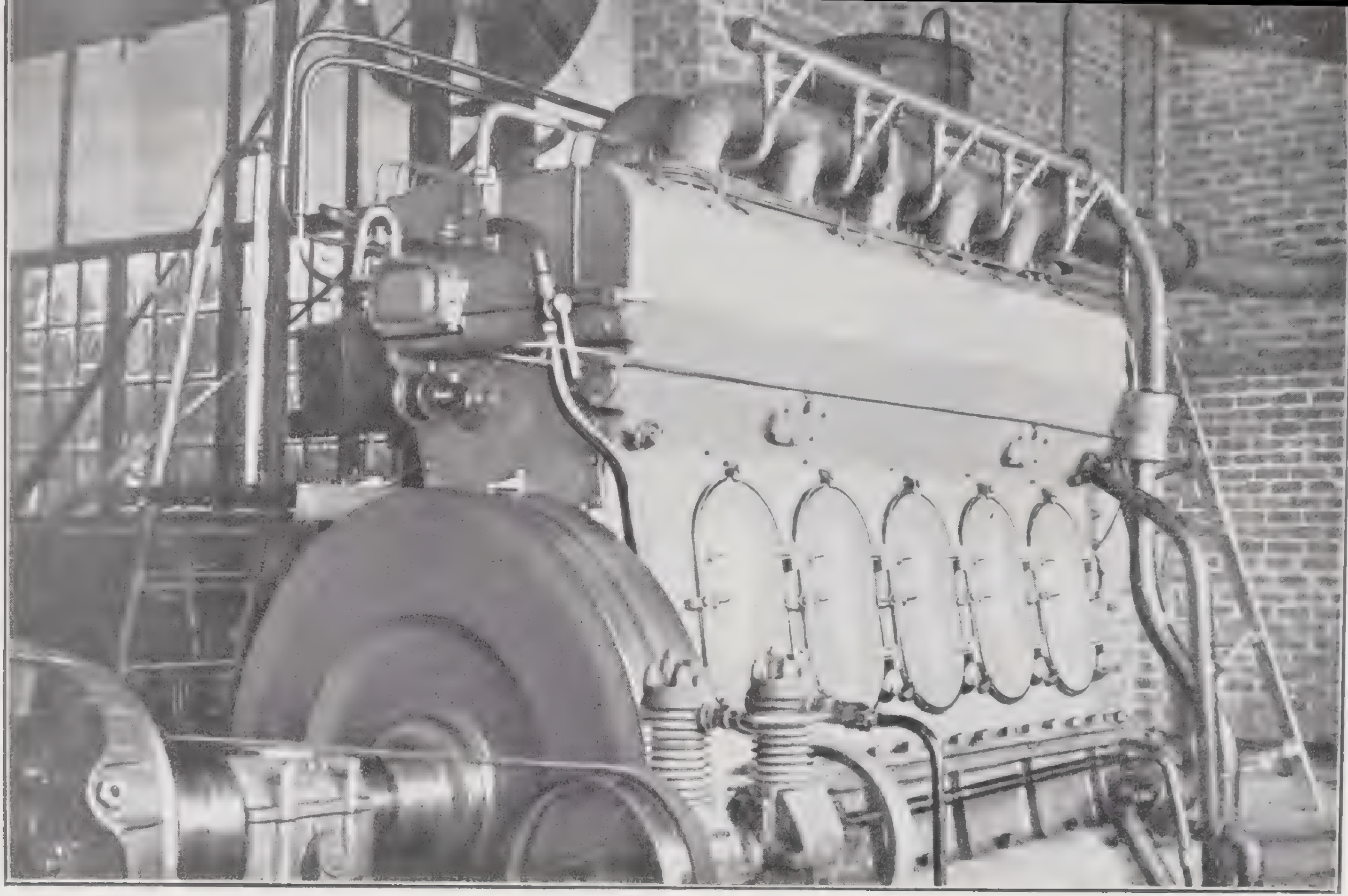
It is not good to empty the whole of the water out of a boiler immediately after blowing off steam. The sudden and irregular cooling down is liable to cause certain parts to get unduly strained. If it has to be emptied for repairs, better let it stand all night and run the water off in the morning.

LAGGING

All parts of boilers and steam pipes which are not bricked in should be covered with asbestos or other lagging, to prevent waste of heat by radiation. The less steam piping the better, and the fewer bends the better.

SUCTION GAS PLANTS

In some gardens suction gas engines are used. The installation includes a plant for the production of suction



A Modern Oil Engine.

gas directly from anthracite coal, or from coke, charcoal or wood. The whole plant occupies quite a small space, and the cost of running the engine by this means is in many instances so small as to be highly economical. The suction gas installation is also often found to work much cheaper than the ordinary steam engine, and it ought to prove satisfactory on tea estates wherever suitable coal, wood, or charcoal can be had.

OIL ENGINES

There are many makes of oil engines used in tea factories nowadays, among which may be mentioned the Crossley, Ruston-Hornsby, National, Tangye, and those smaller types such as the Lister and Petter, generally used for small power jobs such as battery charging, lighting, pumping, etc. The large type of vertical multi-cylinder Diesel or semi-Diesel has of recent years become very popular.

VERTICAL ENGINES

For small engines up to 10 horse-power the vertical shape is the most economical and lasting, although it may not look so imposing as the horizontal. In the vertical engine, the wear on the piston and interior of cylinder is quite even, and is very slight, so that after ten years' use the piston is probably almost as good as new, whereas in the horizontal engine the weight of the piston, etc., tends to make it wear down and become uneven, the cylinder itself getting worn slightly oval, so that in course of time costly repairs become necessary, if a considerable waste of power as well as fuel and lubricant is to be avoided.

OIL FUEL

Oil engines constitute probably the commonest form of power nowadays in tea. Even for steam engines it is found economical to use oil fuel in places where

coal is scarce or expensive. Boiler furnaces can easily be altered and adapted for burning oil.

WASTE OF POWER—AUXILIARY ENGINES

For a large factory, it is not advisable to get one great engine, capable of driving the whole of the machinery and some power to spare. The larger the engine, the greater the amount of friction on the working parts, so that, when very little leaf is coming in and only a portion of the machinery at work, there is great waste of fuel in running an engine of say twice or three times the horse-power required in order to work the factory. The same thing occurs when, during the night, withering fans have to be run, although no other machinery is required at the same time. The better plan is to have one engine which is capable of driving the greater part of the machinery, with one or two auxiliary engines which are capable of working a small portion of the machinery when the factory is not in full operation. Where more than two fans are required for withering purposes, it will pay to have a small engine or electric motors to work these alone.

HOT BEARINGS

Shafting should run perfectly true, and the bearings all perfectly level and in line. Ball or roller bearings are best, wherever possible.

If any bearing gets hot, it is an indication of something wrong, which should be put right as soon as possible. Unnecessarily heavy shafting is to be avoided, because when running free it takes fully twice the power to turn any shaft which is twice the size of another. Very extensive shafting also means a great deal of friction and consequent loss of power; hence it is desirable to have the machinery arranged as compactly as possible and to keep running only as much shafting as is necessary. In many factories the use of a clutch between the rolling room shafting and the remainder, obviates the

need to have the shafting for the rollers in motion when this part of the factory has ceased work.

LUBRICATORS

Only good oil should be used, and every journal supplied with a syphon or lubricator : these being always kept clean and in working order.

BELTS

For main belts the rope system is in favour in some large factories; it takes an excellent grip and is not heavy. Ordinary cotton belting is also very suitable for this purpose, provided it is of the best quality; but it must never have resin applied to it or be allowed to get wet, in which case it rots rapidly. India rubber belts will not stand heat.

For belts which require to be shifted for starting and stopping machines, leather is perhaps best; it must be the best leather, however, and it should occasionally have a coating of castor oil or other suitable dressing to keep it soft. Fibre belting is most commonly used however.

LENGTH OF BELTS

Belts never run well when the distance between their pulleys is very short. About 20 to 30 feet is a good workable distance for machine-driving belts. When they are very short, they have to be kept very tight, which is exceedingly bad for the material. On the other hand, when belts are very long, they are heavy, and so add very much to the friction on the journals.

RULES FOR BELTING—PULL ON BELT

Belts should not be made to run vertically, because in that position it is almost impossible to get a proper grip on the lower pulley, and the belt must in consequence be kept abnormally tight. Thus it may be

summarized—1st, that belts require to run as nearly horizontal as possible; 2nd, they need to be of good length; and 3rd, never drawn very tight. It is an advantage also that the pull on a belt should be on the lower stretch, then whatever slackness there may be will be on the upper stretch and the drooping of it only tends to make the belt cling closer to the pulleys.

DOUBLE BELTS

Double belts are not satisfactory. If a single belt is not sufficient to bear the required strain, better run another single one on the top of it; sometimes three belts are run in this way and do exceedingly well. The belting should be a good deal stronger than what is actually required, and it will then have a much longer life than if continually strained almost to the breaking point. Leather link belts are greatly in favour in English factories, whenever great strength is required.

Double leather belts—two belts sewn together—are not advisable, as they very soon come apart.

PULL OPPOSITE

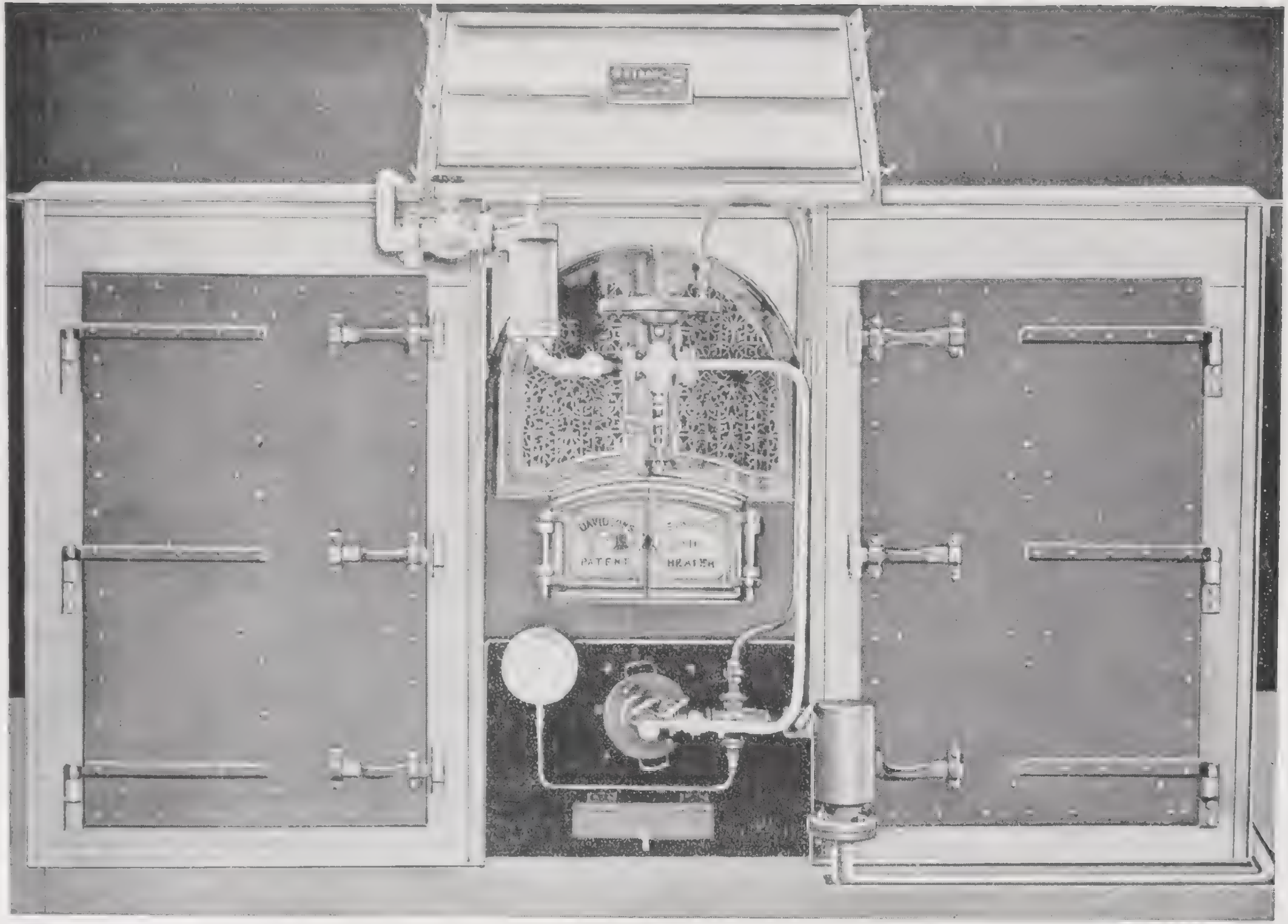
Shafting and machines should be arranged so that belts are made to pull alternately on opposite ways on the same shaft, and so to a large extent balance the pull and reduce friction on the shaft bearings.

BELT STRETCHERS

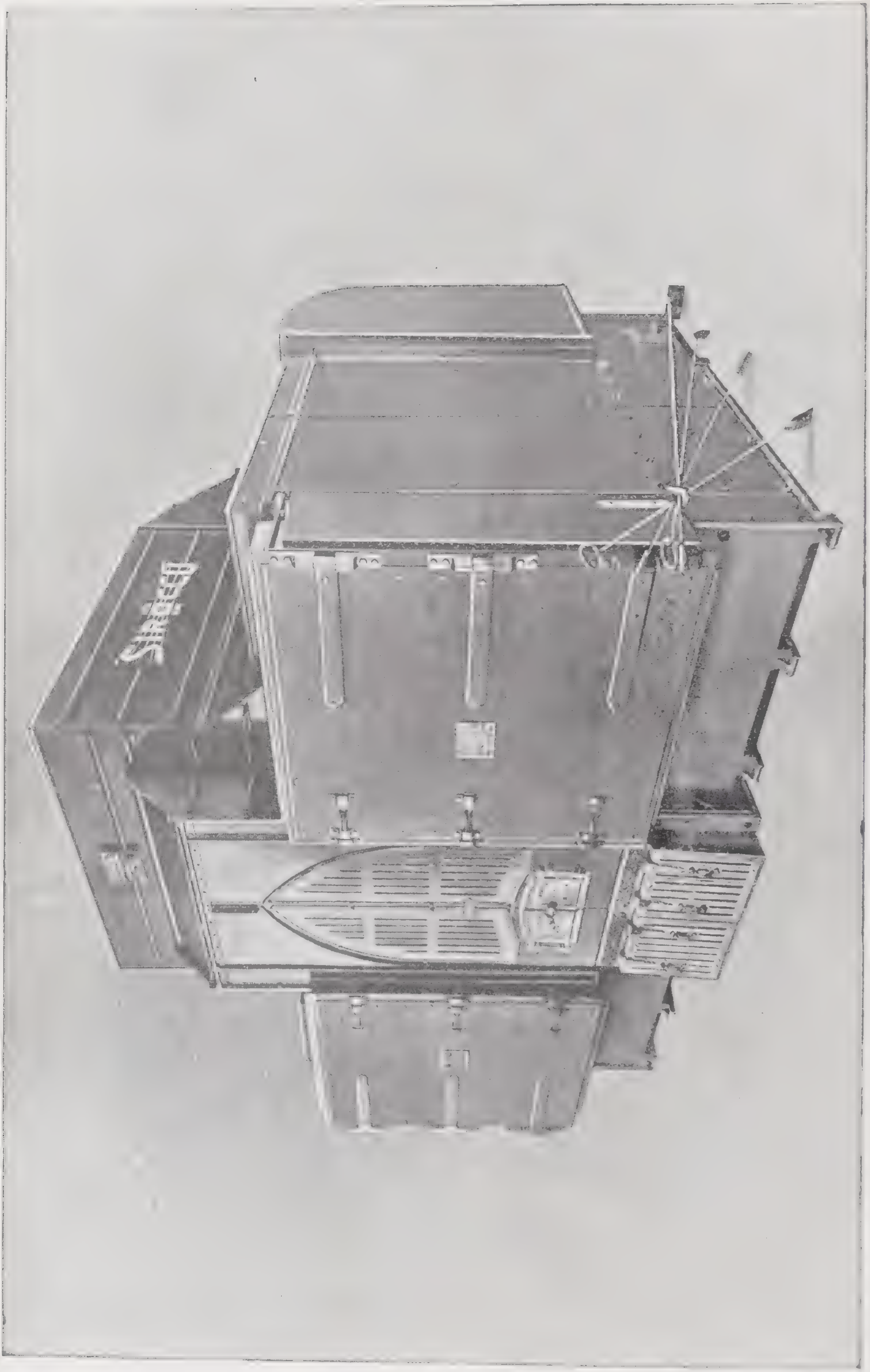
No belt which is wider than four or five inches should be sprung into position. It should be joined up in position on its pulleys with the aid of a belt stretcher of some sort.

TEA MACHINERY-ROLLERS

There is a considerable choice of machinery for tea manufacture on the market at the present time. As far as rolling tables are concerned, both the single and double action type are available, in different sizes.



"Sirocco Wallsend" Oil Burning Equipment.



The commonest makes are those of Messrs. Davidson, Britannia Eng. Co. and Marshall & Sons.

The latest types are the "High Efficiency" Britannia machine; the "Senior" O.C.B. made by Messrs. Davidsons (Sirocco Eng. Works); and Messrs. Marshall & Sons. Mark II Rigid Rapid. Two machines, the $46\frac{1}{2}$ Senior O.C.B. and the 46″ High Efficiency rollers will take charges up to eight or even ten maunds of leaf. The products of all three firms are excellent machines and any distinction between them would be invidious. Modern rollers are run on ball or roller bearings, and though heavier and more robust than the older types, can be run practically noiselessly and with much less power.

Care has been taken to make these modern machines easy to clean; caps are easily removed, and the tables are in one piece of metal with solid battens, instead of being in sections of brass screwed to a wood base. Wood has in fact been entirely eliminated from modern rollers.

GREEN LEAF SIFTERS—C. T. C. MACHINE

Many people still adhere to the rotary system of kutcha sifting, though the flat type has many advantages if used properly. Machinery manufacturers in India have studied this phase of tea manufacture in some detail, and have evolved a very good sifter—the Balanced green leaf sifter, made by Messrs. Britannia.

Many flat sifters are fitted with ball breakers; these being rotating paddles working in a box or hopper at the feed end of the sifter. As the leaf is fed in it is hit by the paddles, resulting in the breaking up of balls of leaf, and at the same time cooling the leaf. A machine called the "Foursome" Sifter has been evolved by a Dooars planter, which has proved very successful for cooling, sifting and extracting stalk from the leaf especially when used in connection with the "no wither" or C.T.C. manufacture. This machine is marketed by

Messrs. Davidson & Co. The machine known as the McKercher Patent "C.T.C." machine is marketed by Messrs. Marshall & Sons, who also supply the well-known Empire and Venetian Driers.

TEA DRIERS

The former type of drier is normally used for first firing and is generally seen in the 4-foot and 6-foot sizes in North-East India. Their latest models, the "Quality" driers, are reported to be excellent machines with many improvements on the older machines, such as economy in fuel consumption; automatic removal of the tea which drops to the bottom of the machine; and greater air space per unit area of tray. This latter improvement has been effected by reducing the size of the perforations, and bringing them closer together, though rigidity of the tray is not impaired thereby.

Machine used		Approximate output of finished tea per hour, lbs.
First firing.	Second firing.	
6 ft. E. C. P. ...	Duplex Tilting Tray	450
4 ft. E. C. P. ...	Single ,,	235
6 ft. Empire ...	10 ft. Venetian	500
4 ft. Empire ...	6 ft. ,,	275

Other machines of no less excellent quality are the Super E. C. P's of Messrs. Davidson's and the Multiflu driers patented by Farbridge.

The Tilting Tray Siroccos and the Imperial Venetians, made respectively by Messrs. Davidson's and Messrs. Marshall's, are excellent machines for second firing.

As a guide to the output of firing machines the following table has been compiled. It is assumed that a good wither has been obtained.

Sorting and packing machinery is made by the three firms mentioned above, and others. Among the best of the mechanical sorters are the Chalmer's, Arnott's, Marshall's Four Tray, Magic and Moore's, also the more recent Mackintosh and Dixon sorters.

CHAPTER XXIV

RAILWAYS AND TRAMWAYS

SLEEPERS

On some large estates, with outlying gardens at a distance, tramway lines have been found exceedingly useful. In a matter like this, however, it is very easy to go too far, and to expend an amount of capital which is not justified by the actual saving of labour effected. It is very seldom that steam power can be necessary for such a line; the rails can be quite light and inexpensive, but the sleepers must be of the best material, because soft timbers will not last long, and a good deal of money soon goes away in constant renewals.

ADVANTAGES

The chief benefit effected by tramways is that leaf can be brought expeditiously from a distance before it has had time to heat and get spoiled. Another advantage is the saving of labour; two men can push along at a trotting pace a load which ten men could not carry. Lines cannot be laid everywhere, however, and they can only be advantageous where long distances have to be traversed and where no engineering difficulties block the way.

It is an additional benefit if the line is laid along a route where fuel, etc., has to be carried in the cold weather.

RAILWAYS FOR TOP DRESSING

On some estates the leaf tramways have been used with great advantage for carrying soil and manure for top dressing in the off season. All these items have to be taken into consideration when estimating the desirability for constructing such a line.

WIRE TRAMWAYS

Wire tramways have come to be very largely used in the hill districts of India and Ceylon, chiefly for carrying leaf across ravines, and from distant parts of the estate to the factory.

There are several systems of wire tramways in use. The oldest of these consists in an endless wire rope passed round a large grooved pulley at each terminal station. When one pulley is set in motion the whole moves in unison. The old plan is to have two trucks fixed to the rope in such a way that when one is going, the other is returning, and with the wire working on a sufficient slope, the weight of the loaded truck going down the slope sets the whole in motion and brings up the empty truck on the opposite line.

UPHILL WORK—CONTINUOUS LINES

The advantage of this system is that it can be worked on any steep slope, and the speed can be controlled by a brake on the pulley at either end. For loads going downhill it works automatically, but for level ground or uphill, power of some sort is required. Where power is used and much material has to be carried, it is customary to have the rope going continuously, and the carriers with the loads are not fixed permanently to the rope, but hitched on one after the other as frequently as required.

SUPPORTS

Wherever the line crosses a valley or a gorge, it goes suspended in the air, but whenever it comes near the ground, suitable supports have to be added to keep the wire up, and so keep the passing load at a safe height. The support is merely a column or post, with a cross bar forming a supporting arm at each side.

DOUBLE ARRANGEMENT OF WIRES

An improvement on the above system is in use whereby the weight and friction of the working parts

is very much lessened. Two strong wire ropes are permanently fixed at the terminal stations. The carriers containing the loads have each a little pulley for running on the fixed wire. An endless wire is passed round terminal pulleys similar to those described above, and is arranged to travel immediately under the fixed wire. This wire rope is quite thin and light. The carriers which run upon the heavy wire are fixed to the light wire and so carried along, the light wire doing the haulage only, while the fixed heavy wire carries the weight. The carrier with its load is kicked off automatically at destination.

SINGLE WIRE ROPE—WORKABLE SLOPE

The most common and useful style of wire tramway is a very simple arrangement, but it can only be used for carrying loads downhill, and then only at a slope of about six or seven degrees; if less slope is used, the loads may sometimes stick half-way, and if a greater slope is used, the loads arrive with destructive force at the terminal.

WINDING ARRANGEMENT

This tramway or "shoot" consists of a single fixed wire. The upper end may be fixed to a large tree, or anchored permanently to the ground. It is important that the winding, or tightening arrangement, should be at the lower end, as it is very difficult to pull the upper end with the whole weight of the rope upon it.

The winding arrangement is in the form of a crab winch; the drum for the rope is about 12 inches in diameter and is moved by worm gear, so that there is no possibility of the thing unwinding of itself. The winding apparatus must, of course, be firmly anchored to the ground.

POSSIBLE LENGTH UNSUPPORTED—DIMENSIONS

In the Darjeeling district there is a garden which has a wire tramway stretching across a valley, the

Wire Ropeways.

distance between the terminals being a mile and a half, without support of any kind. It has been in use for several years, and carries a load of 40 lbs. with perfect safety. This may, therefore, be taken as a possible stretch. The wire is of the description termed "Lang's Lay", which is the best style of spinning wire rope, and it is of the best steel; the circumference is 1½ inches or about ½ inch diameter. For moderate stretches, 1⅛ inches circumference is sufficiently strong, if the material is of the best.

For work of this kind, an improved class of rope is now being introduced. The strands are of solid wire, instead of being compound. This rope is less flexible, but wears very much longer. A fixed rope does not require to be very flexible.

SHORT TRAMWAYS

For short stretches, up to half a mile, the upper end of the rope may be fixed to a large tree, and the winding arrangements may be made of timber, the drum being a piece of tree trunk with holes drilled in it for crowbars with which to wind it round. When the rope is sufficiently taut, a crowbar is inserted in a suitable hole and a batten is put across behind the crowbar by which means the drum is kept from unwinding.

TIGHT ROPES

It is important that the rope should not be stretched very tight, which means a great strain upon everything, and it will work just as well when comparatively loose.

RUNNERS

The carriers or runners are simply little grooved pulleys about 3 or 4 inches diameter with hooks attached, to which the load is hung.

Some kinds of runners have an awkward tendency to jump off the line, endangering the lives of any people who may be passing below. The safe kind is that which

has a shield coming over the outside of the pulley to guide the rope back into its place again in case of vibration and jerking.

ONE AT A TIME

In the case of long stretches of rope, care must be exercised to ensure that only one load is on the rope at a time, otherwise disaster may occur.

RETURNING EMPTIES

With tramways of this sort, the runners, with the empty baskets or bags, must be carried back by hand to the starting point for future use.

WIRE TRAMWAYS FOR TOP DRESSING

Tramways up to half a mile long can be used on hill gardens for top dressing with great advantage in the off season. It often happens that there is fine soil for this purpose available, but at a place where distance and natural obstacles render the use of it impracticable unless by means of the wire tramway, which is thus eminently profitable. The saving of labour in this work is enormously greater than in leaf carrying. In this latter case a line may be required to carry only a few loads per day, but when used for top dressing, it is in use all the time and may carry up to a thousand loads each day.

In the case of carrying leaf the chief benefit is in getting the leaf swiftly to the factory from a distance without heating or damage.

Some sort of buffer is necessary at the lower terminal of the tramway, and various devices have been invented for this purpose. Some of these buffers are rather severe upon the rope itself. A simple and effective style of buffer can be made by banking up a mound of dry earth, against which the load strikes on arrival. This causes very little damage to the load, and of course the buffer is indestructible.

APPENDICES

APPENDIX I

USEFUL TABLES

Number of tea bushes per acre

Feet apart.	Method of planting.	
	Triangular.	Square.
6 × 6	1,398	1,210
5½ × 5½	1,662	1,440
5 × 5	2,011	1,742
4½ × 4½	2,483	2,150
4¼ × 4¼	2,785	2,411
4 × 4	3,143	2,722
3½ × 3½	4,120	3,560

Number of shade trees per acre

Feet apart.	Method of planting.	
	Triangular.	Square.
60 × 60	19	12
54 × 54	22	15
51 × 51	26	16½
50 × 50	27	17½
45 × 45	33½	21½
42½ × 42½ ...	37½	24
40 × 40	42½	27
36 × 36	52	33½

The formula for square planting is no. per acre $= \dfrac{43560}{\text{distance apart squared}}$

and for triangular planting no. per acre $= \dfrac{50298}{\text{distance apart squared.}}$

In both cases the distance apart is in feet.

Land measures

4,840 square yards	... ...	= 1 acre.
640 acres	... ...	= 1 square mile.
1 null	... ...	= 144 sq. feet.

Assam land measure

144 sq. ft.	make	1 locha.
20 lochas	,,	1 cotha.
5 cothas		1 halisa or bigha.
4 bighas	,,	1 pura.

1 bigha = 1,600 sq. yds. = approx. ⅓ acre.

Bengal land measure

16 chataks	make	1 cotta.
20 cottas	,,	1 bigha.

1 bigha = 1,600 sq. yds. = approx. ⅓ acre.

Weight in lbs. of 1 cubic foot of various materials.

		lbs.
Water	... ...	62·28
Iron, cast	... ...	430—467
,, wrought	... ...	461—486
Wood	Nahor (Nagessar)	70
	Sal	60
	Teak	58
	Toon	35
Aluminium	... ...	160—168
Brick	... ...	85—118
Stone	... ...	125—165
Concrete (mean)	... ...	140
River sand (dry)	... ...	115
Cement (loose dry)	... ...	80—90
Dry clay	... ...	120
Coal	... ...	79—82

Conversion table. English to metric system

2·540 centimetres	... ...	= 1 inch.
0·9144 metre	... ...	= 1 yard.
28·35 grams	... ...	= 1 ounce.
4·546 litres	... ...	= 1 gallon.

Indian and English weights. (*Official*)

5 tolas ...	= 1 chittack	= 2 $\frac{2}{35}$ ounces.
16 chittacks ...	= 1 seer	= 2 $\frac{2}{35}$ pounds.
40 seers ...	= 1 maund	= 82 $\frac{2}{7}$ pounds.
27·22 maunds ...	= 1 ton.	

Number of tea seed to the maund

Large Assam light leaf or Manipuri ...	13,000 to 15,000
Small dark leaf Burma and China ...	18,000 to 22,000

1 maund seed gives 7,000 to 10,000 good plants, sufficient to plant 2½—4 acres of tea under average conditions. At 8 inches triangular planting in the nursery, 1 acre of nursery takes about 4 maunds seed of average size.

HUMIDITY TABLES

Showing relative humidity at different wet and dry bulb temperatures.

et.	Dry.	Humidity.	Wet.	Dry.	Humidity.	Wet.	Dry.	Humidity.
F.	°F.	Per cent.	°F.	°F.	Per cent.	°F.	°F.	Per cent.
74	74	100	75	75	100	76	76	100
	75	95		76	95		77	95
	76	90		77	91		78	91
	77	86		78	86		79	86
	78	82		79	82		80	82
	79	78		80	78		81	78
	80	74		81	74		82	75
	81	70		82	71		83	71
	82	67		83	67		84	68
	83	64		84	64		85	64
	84	60		85	61		86	61
77	77	100	78	78	100	79	79	100
	78	95		79	95		80	95
	79	91		80	91		81	91
	80	87		81	87		82	87
	81	83		82	83		83	83
	82	79		83	79		84	79
	83	75		84	75		85	76
	84	71		85	72		86	72
	85	68		86	68		87	69
	86	65		87	65		88	66
	87	62		88	62		89	63
80	80	100	81	81	100	82	82	100
	81	95		82	96		83	96
	82	91		83	91		84	91
	83	87		84	87		85	87
	84	83		85	83		86	84
	85	79		86	80		87	80
	86	76		87	76		88	76
	87	72		88	73		89	73
	88	69		89	69		90	70
	89	66		90	66		91	67
	90	63		91	63		92	64
83	83	100	84	84	100	85	85	100
	84	96		85	96		86	96
	85	91		86	92		87	92
	86	88		87	88		88	88
	87	84		88	84		89	84
	88	80		89	80		90	80
	89	77		90	77		91	77
	90	73		91	74		92	74
	91	70		92	70		93	71
	92	67		93	67		94	68
	93	64		94	64		95	65

APPENDIX II

GLOSSARY OF VERNACULAR TERMS USED IN TEA

Banjhi ... (= sterile). Applied to a terminal shoot which is dormant. The bud is much smaller than a normally growing bud and remains in this condition while the leaves below it continue growing. Thus if a shoot of two leaves and a banjhi bud is plucked, the leaves are generally of much coarser texture than those of a normal shoot of two leaves and a growing bud. It is therefore usual, in fine or medium-fine plucking, to pluck off the banjhi shoot with only one leaf; if this leaf is soft, i.e., young, it is included with the rest of the leaf for manufacture, otherwise it is thrown away.

Barri ... A piece of cultivated land, generally understood to refer to an enclosed area of comparatively small extent, such as a vegetable garden. Tea seed gardens are usually referred to as barries.

Bagan, or Baghichar. Larger cultivated area such as a tea estate.

Bela ... (= a period). Used to denote a period of work done by the labourer, e.g., morning bela from, say, 8-0 A.M. to midday.

Bheel ... (= swamp). Some areas in the Surma Valley at the foot of low hills were swamps until drained and planted with tea. The soils of these areas are rich peats, on which enormous crops have been obtained. Bheel soils often contain over 30 per cent organic matter and over half a per cent of nitrogen.

Bheti, dela, bhindi. Terms used for the ball or cylinder of soil which encloses the roots of a plant when transplanting it. Bheti actually means a raised bed of earth, and is used in this sense to describe the raised plinth of a building. Dela is the Bengali word for a lump; bhindi also has the same meaning and is commonly used in North Bengal. Dela is used in the Dooars and Surma Valley; bheti in Assam.

Bund ... A ridge or embankment; may refer to a small ridge of soil made to stop surface wash or a road or railway embankment.

Cheel, chool ... Used to describe a form of cultivation in which the surface of the soil is scraped to suppress weeds. As little of the soil itself as possible is disturbed and the weeds are generally collected into low ridges between the rows of tea.

Callam ... A cut or prune. Beri-callam is a heavy prune; bich-callam a medium prune.

Chula ... A small brick furnace fired by charcoal used at one time for drying tea. Fumes of the charcoal came into direct contact with the tea.

Dhol-guri ... The fine leaf or tea which falls to the bottom of the drier. *Dhol* means that which falls or pours down, while *guri* means fine or powdery.

Gap ... *Gaping* is the term used in Assam for the final firing of tea before packing. In other parts the term *pucca-batti* is used.

Ghani ... The term used for a batch of leaf going into or taken from a roller or rollers, or going into the fermenting room or drier. The day's manufacture is divided into so many ghanis, the quantity in each ghani depending on the capacity of the rolling and firing machinery.

Hoola ... A term used in Assam for an elongated depression or water-course, generally dry in the cold weather.

Jat ... Jat as applied to tea indicates the progeny of a particular seed garden, not of any distinct race, type, strain or variety. In the case of seed collected from plants growing wild, jat indicates the progeny of the plants growing wild (or apparently wild) in any particular area of country.

Janam ... (= birth). When shoots on a bush "come away" after a period of dormancy, small leaflets (termed *cataphylls* by botanists) are first unfolded, before the true leaves appear. These small leaflets are *"janams"*. Usually only one or two are of appreciable size and remain attached to the stem for any time. The other very small ones are either hardly perceptible, or fall off. Sometimes the leaflet below the first big leaf is almost a normal leaf—but is rather smaller with no pronounced serrations or point. It is often called a *gol-pat* in Assam.

Kamjari ... The Assamese term for the day's work.

Kodali ... An implement for hoeing.

Khurpy ... A small hand fork. *Kurpying* and *thullying* are terms used to describe the operation of hand forking round a bush or plant, to remove weeds.

Kunchi ... A term used in the Surma Valley for narrow flat piece of land between hillocks or *teelas*.

Kutcha sift ... Separation of coarse and fine leaf after rolling.

Mal ... Rolled or fermented leaf.
Guri or *dhooli mal*=fine leaf sifted out after rolling.
Gota or *mota mal*=the coarser portion of rolled leaf.

Nallah ... A drain.

Null ... Bengal and Assam land measure 1 null=144 sq. ft. *Lagi* is used in North Bengal for the same measure.

Pacca-batti ... Synonymous with *"gaping"*—i.e., final firing.

Pie ... A corruption of *pari* used in Assam to indicate a line or row of tea. The word *deng* is used synonymously in Bengal.

Pulli ... A young plant.

Rung ... Rolled or fermented leaf.

Roga mulla ... A kind of mistletoe (*loranthus* species), parasitic on shade and other trees, and on tea plants especially in seed gardens.

Teela ... Term used in the Surma Valley for a hillock or low hill.

APPENDIX III

PERCENTAGE WEIGHT OF VARIOUS PARTS OF A TEA SHOOT

	In a shoot of two leaves and a bud, per cent.
Bud	15
First leaf	20
Second leaf	40
Stalk	25

	In a shoot of three leaves and a bud, per cent.
Bud	7
First leaf	8
Second leaf	15
Third leaf	35
Stalk	35

The above are averages for many typical shoots off pruned tea in mid-season.

Moisture in green leaf

Taken at the beginning of	Moisture percentage.	Taken at the beginning of	Moisture percentage.
April ...	79 (tippings)	September ...	77
May ...	74	October ...	76½
June ...	75	November ...	76
August ...	77½	December ...	75

N.B.—Leaf with surface moisture varies up to 83 per cent total moisture.

Moisture in various parts of the shoot

(*a*) Shoots plucked in the second flush :—

	Per cent moisture.
Bud	74
First leaf	72½
Second leaf	72½
Stalk	82

(*b*) Shoots plucked in the rains :—

	Per cent moisture.
Bud	78
First leaf	76
Second leaf	76
Stalk	84½

Analysis of dried green tea shoot

	Per cent.
Tannin	25
Protein	22
Caffeine	4½
Starch	½
Sugars	3
Gums, pectins, etc.	7
Cellulose	14
Fats and waxes	1½
Ash	5½
Amino-acids	9
Chlorophyll and other pigments	½
Total soluble in boiling water	45

Typical analysis of a sample of finished tea

	Percentage.
Water	9·0
Nitrogen compounds	21·0
Caffeine	4·3
Ethereal oil	0·6
Fat, wax, and green colouring matter	3·6
Gum and dextrin	7·1
Tannin	13·0
Other substances free from Nitrogen	16·0
Wood fibre	20·3
Ash (mineral salts)	5·1

When a tea is extracted for five minutes with boiling water, one-half or two-thirds of the total tannin and about three-quarters of the total caffeine dissolve out. The total amount of solid matter extracted by boiling is about 40 per cent of the original weight of tea taken, and half of this is extracted in a five-minute infusion.

APPENDIX IV

METHOD OF TAKING SOIL SAMPLES FOR ANALYSIS

Soils often vary greatly from place to place and a single clod of earth cut from one place can only by accident truly represent the section from which it was taken. Manures also are not always evenly applied, and such a single piece of earth may include, for example, a lump of lime or of animal meal, so that the analysis might give a very wrong idea of the real average soil.

The bulk sample sent for analysis should always be a mixture of a number of small samples taken in different places from both good and bad patches of tea.

The following procedure is recommended :—

Select a patch of soil about 30 yards square, which appears fairly to represent the section to be sampled, in colour and mixture, and in size and health of tea bushes.

Within this area samples should be taken from at least ten different points.

Generally a sample of surface soil only, to 9 inches depth, is required. This is most easily taken with an ordinary carpenter's auger (2 inches diameter). This should be screwed into 9 inches depth, withdrawn by a straight pull, and the adhering soil rubbed off into a box.

For full analysis about 3 lbs. soil are required. If only soil acidity, nitrogen and loss on ignition are required, 1 lb. is sufficient, of the top 9 inches only.

A 2-inch auger takes about 1½ ozs. of soil, so that about ten to thirty such borings will be necessary.

Sometimes the surface and subsoil may be markedly different. A layer of clay may overlie sand or *vice versa;* clay or sand may overlie peat or *vice versa.* In that case a sample of the subsoil should also be taken, and described, for example, thus :—

Sample No. 1.—Section No. 8, top 9 inches.

Sample No. 2.—Section No. 8, subsoil 12 inches to 21 inches.

The earth auger may also be used to take subsoil samples. When the top 9 inches has been removed in taking the sample of surface soil, the auger should be screwed in to 12 inches (or other depth at which different soil occurs), withdrawn and adhering soil thrown away. The auger is then screwed in to a further 9 inches, pulled out, and adhering soil collected.

If the soil is loose and dry, it will not adhere to the augur. Samples should, for this reason, be taken when the soil is moist, or sufficiently compact to adhere to the auger.

When a sample is taken it should always be marked with the number or name of the section from which it comes.

Information which should accompany a soil analysis

The reason for sending the analysis should be given. It saves unnecessary writing if it is stated whether the land is virgin, jungle or old tea land proposed for nurseries tea in fair condition for which a maintenance programme of manuring is required, or poor tea thought to require particularly good treatment. Poor tea may be growing on

good soil, or good tea on poor soil if well treated. The constitution of the soil is only one of the factors which affect growth.

The following information therefore should be given :—

(1) Age of tea.
(2) Jat of tea.
(3) Distance apart of planting.
(4) Notes on drainage and lie of land.
(5) Pruning for last five years.
(6) Manuring for last five years.
(7) Yields for last five years.
(8) Pests and blights recognized to be present, if any; and treatment given, if any.
(9) Whether tea is shaded, and if so, kind of tree used and distance apart.
(10) Condition of roots, and nature of root growth.
(11) Colour of soil.

If a manuring programme is required to be suggested the following information should also be given :—

(*a*) Total area to be manured.
(*b*) Number of acres which can be given cattle manure at five tons per acre, or top dressing.
(*c*) Number of acres which can be given semi-permanent green crops, e.g., boga medeloa, arhar.
(*d*) Price at which oilcake is obtainable, locally.
(*e*) Amount per acre proposed to be expended annually in manuring.

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